INTEGRATED EDITION OF THE PETROLEUM ENGINEER

the Petroleum Engineer

FOR MANAGEMENT

FEBRUARY 1960

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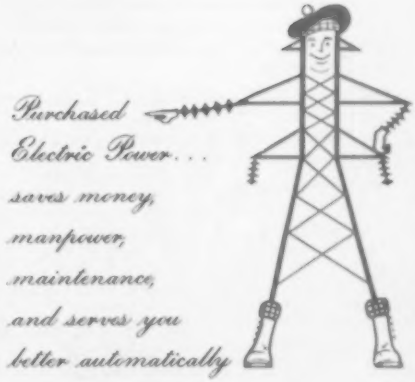

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THE PETROLEUM Engineer

FOR MANAGEMENT

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OUR COMMON COMPETITION . . . WILL RUMANIA PAY? . . . SPANISH SAHARA DOTTED WITH CONCESSIONS . . . IMPORT QUOTA FOR WHALE OIL . . .

Forecast up 3.6%. Consumption of domestic crude oil was estimated at 7,480,000 b/d for February 1960, compared to 7,216,700 b/d for same month last year by Bureau of Mines.

Little ones get bigger. Mergers and purchases of oil companies you see in the papers gives some hair-tearers a chance to chant, "the big ones get bigger – eating up the little ones." But General E. O. Thompson, at a dinner honoring him in Dallas, Texas, said there were 600 new oil producers (not royalty owners) in Texas in 1959 bringing total to about 6000. Those little ones won't stop either, it seems.

A spot of cheer. In looking over the Residual Fuel Oil Import list from the Department of Interior, we are happy to report to you that Whale Oil Company had a quota of 58,696 bbl for the last half of 1959. At least whales are still out of competition.

Tut, tut, California! Of the highway tax funds collected in California, in 1958, more than $88 million or 16% was diverted to other purposes. *Oil Facts* shows this as the largest amount though not the largest percentage. The API publication estimates diverted funds would have built 1000 miles of highways that year.

Pure buys Woodley. Under the plan approved by boards of both firms, Pure Oil will exchange stock for nearly all the assets of Woodley Petroleum, Houston. Founded in 1922, Woodley owns over 300 wells in the U. S. and Canada, has interests in three pipelines and a Minnesota refinery.

Try loan business. Imperial Oil, Ltd., is making second mortgage loans to new Canadian home owners to finance installation of oil heating equipment. The plan, based on 7-year payment at 6% with the home as security, apparently works well. British Columbia Electric Company has a similar plan for natural gas equipment. What would happen if oil and gas producers got into this business?

Add gas. Federal Reserve Board's new index of industrial production has added a new category — electric power and natural gas. This and other new data raised the index 7%. Can anybody figure why it took so long to measure natural gas energy in productivity?

Brand new spot. U. S. companies have finally been awarded concessions in Spanish Sahara, Northwest Africa. Some went to joint American-Spanish companies. INI, Spanish government's entity, was not specially favored. It received 4 blocks. Caltex, awarded 6 blocks, was chief winner.

U. S. competition. If you haven't clear in your mind which countries are "Common Market" and which are "Outer Seven," you can see them here. Both groups are lowering tariffs among their members and rivalry is strong between the two. Long-term results may be good for everybody; short-term competition is going to hurt inflated Uncle Sam.

Humble grows. Esso Standard Oil Company and Carter Oil Company have been merged into the new Humble Oil & Refining Company. This is another move in the large-scale merger program announced last September by Humble and Jersey Standard. Oklahoma Oil and Pate Oil Companies will also be in the merger soon.

Straws. Japan has signed a contract to buy 11,500,000 bbl of crude oil from the Soviet in the next 6 years. Price was for less than $2 a bbl. ($14.75 a ton.)

Struck plant open. Standard Oil (Indiana) refinery at Sugar Creek, Missouri, after 6 strike-bound months has boosted production to 83% of capacity. Plant Manager P. C. Livesay said throughput of crude oil is now 62,000 bbl per day. About 600 employees represented by Oil, Chemical & Atomic Workers International Union have been on strike since July 8 over a contract dispute.

Expropriation pay. Negotiations are in process between the U. S. and Rumania on financial matters. Some claims deal with the expropriation of U. S. oil interests in Rumania. The Soviet took these over in 1944.

One for FPC Solomon. In arbitration proceedings a subsidiary of Crescent Petroleum was awarded 23 cents per Mcf for Hugoton field gas, instead of 10½ cents per Mcf now being received from Northern Natural Gas. Now it goes to Federal Power Commission. Decision date not set.

Liberalize laws. Rules for oil and gas exploration in India have been made more attractive to outsiders. You can get a copy of the new laws in "Oil Prospects in India" issued by Indian Ministry of Steel, Mines and Fuel, New Delhi.

Can Labor Increase Productivity?

YOU'VE HEARD THE EXPRESSION used often — output per manhour. In the steel strike discussions, management considered annual increase in productivity was 2 percent; union leaders figured it up to 3.8 percent.

Management says that wages have outdistanced productivity and that's the cause of inflation. Labor says it should have higher wages because it produces more goods in less time.

Let's look into that productivity increase just a minute. What makes output per manhour rise? Two hands can just do so much. Why is it, then, that labor keeps producing more for the time it works.

In the period between 1948 and 1957 Chase Manhattan's economists figured capital assets increased 40 percent while manhours rose only 4.5 percent. Use of more capital, therefore, brought rise in productivity per manhour.

This revelation indicates capital is the key to economic progress. Its importance is emphasized by the fact that today the world is divided in two camps on this one question — should the State or the individual have the use of capital?

From its beginning the petroleum industry has been nurtured by capital. It was a lusty infant — took tons of capital it may never repay. If an accountant's record could have been kept on the whole industry from its beginning, it would doubtless still be in the red. The only record, however, is for the whole economy. Capital put into oil has done more than any one factor to raise the productivity we're talking about. (Don't expect any cheers.)

So let's not get muddled on this increased productivity score — it's due not so much to the workman's skill as to wise use of capital. Wise use of capital has educated scientists and engineers who created productive machines; and it has developed a petroleum industry that supplies the energy to run the machines. Incidentally, from the clamor for capital heard round the world, it must be hard to raise capital in a socialist or communist country.

One danger to increased productivity in the United States is the exposure of growth capital to government raids by higher taxes, by costly regulations, and, in the petroleum industry, by constant attacks on percentage depletion. When corporations and individuals cannot supply enough capital to keep productivity increasing we'll come inevitably to government-financed industry, the most expensive capital. Another danger is the coercive power of unions to push wages ahead of productivity gains, depleting capital and strengthening competition.

Output per man increases as management is enabled to retain capital and put it to work. We're not a nation of handicrafters because we're a nation of capitalists who've studied the wise use of investment in machines and energy.

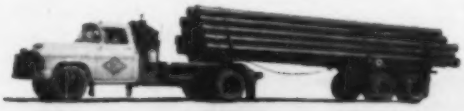
When you're looking for productivity increase — for economic progress — be sure you know what it looks like and what makes it grow.

Ernestine Adams

Congrats and $25 for this quip to DEAN H. CROWELL, 5919 Vickery Boulevard, Dallas, Texas

Joe Roughneck's seen dusters in his day, but he's brought in many a producing well, too. And throughout the years, Joe's been the one to specify Lone Star API pipe. He knows it's tough, dependable and available conveniently in the heart of the oil country.

Made by the oil country's own steel mill, Lone Star casing, tubing and line pipe is known for quality. Our ultramodern plant maintains rigid quality control from ore to finished product.



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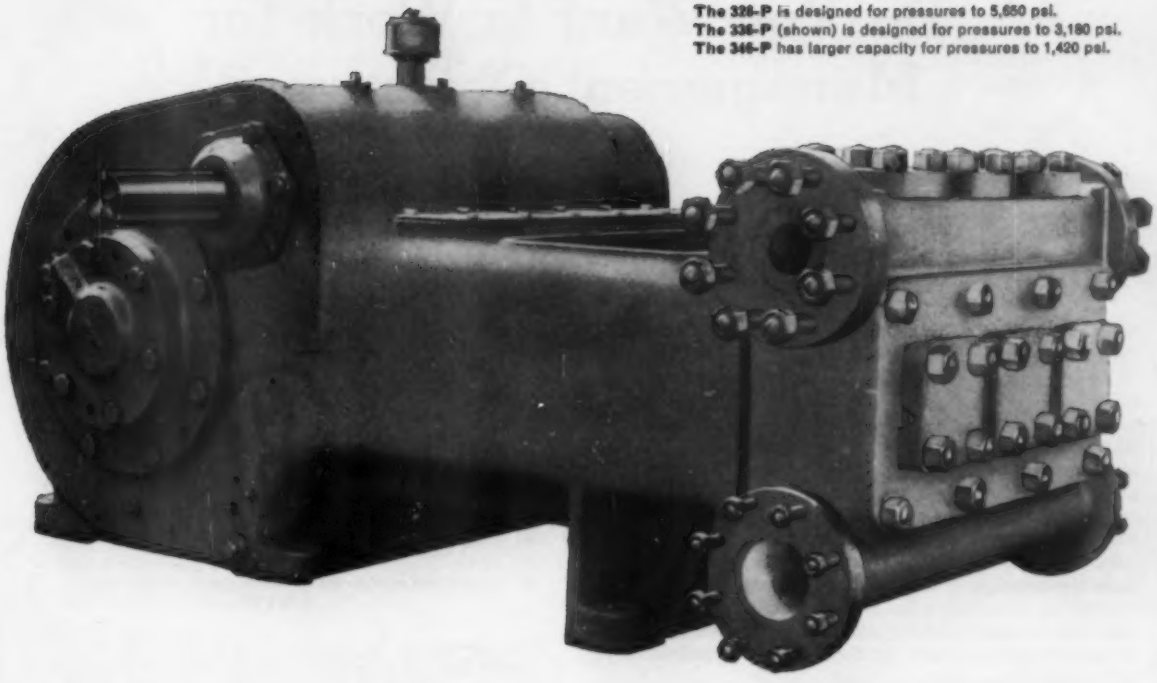

The 328-P is designed for pressures to 5,650 psi.
The 336-P (shown) is designed for pressures to 3,180 psi.
The 346-P has larger capacity for pressures to 1,420 psi.

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Added Up . . . these changes result in lower maintenance costs as well as increased permissible fluid-end pressures and operating speeds . . . to give you more barrels-per-day delivery from each pump.

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HOW TO BE A MANAGER

Do You Want to Work for Management Objectives?

C. H. Trotter

"Know thyself," said the old philosophy;
"Improve thyself," saith the new. — Bulwer

NOT LONG AGO Paul Endacott, president of Phillips Petroleum, said in a meeting of engineers and scientists: "Be it for personal satisfaction and enjoyment or to prepare for greater opportunities, technical people can gain much by broadening their knowledge beyond the boundaries of their regular duties. This has been forcibly brought home to me recently through the failure of three different technically able men to meet with acceptance for a very challenging and rewarding position as top executive of a medium-size company in whose behalf a friend solicited my help. They just had not broadened their qualifications to meet the demands of such a job."

So many personnel in the petroleum industry are technical men and to most of them comes a time when they must decide whether to take on the added responsibilities of management.

Perhaps a little more analysis of the prerequisites of management should come first. Truthfully, we're not certain of the exact answer to the question "How to be a successful manager." It has been asked and answered time after time since it was first posed as one of the chief riddles of our modern industrial era. Sometimes the answers have been compressed into a page or two of print; sometimes they have been broadened into a thick volume. The question itself has no bounds. In a sense, it embraces every ramification of business and industrial life, with significant smatterings from such fields as psychology, finance, law, and various other arts and sciences. This much we do know: It takes hard work and diligent study. You can't play it by ear in this age of speedy competition.

The best we can do in adding to the wealth of answers to this question is to outline certain principles — guideposts, you might call them — which can lead you into an all-important self-analysis. You are the only one who can answer the question — "Do you want to work for management objectives?"

MANAGEMENT IS A PROFESSION

Foremost, it should be stressed that today managing is a profession. As such, it requires professional study and development. A person doesn't inherit the skill of managing

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Will the real manager please stand? He can be a farm boy, a new graduate, a service station worker.

and sometimes we wonder what happens in the life of a young man that makes a service station employee or a farm boy determinedly step into the sometimes rough and hazardous road that finally takes him to the top management of a big company. He doesn't find one certain "key" or technique overnight which will make him a successful manager. For managing, like teaching, is more a matter of study, knowledge, and understanding, than of techniques.

IT REQUIRES SELF-DEVELOPMENT

Managers, and those who realize managing is a profession, recognize that the development of management skills is an individual process. It is not something that is done *to* him, but rather what he does himself. Others can provide opportunities to practice and learn management, but the individual must do the learning and the practicing. And most of all, he must want to.

Although the same principles may apply, there is no single canned or standardized method for this individual development. Each person is unique. Each needs a program to fit his needs. There are probably as many approaches to management development as there are managers being developed.

WORK FIRST ON PRESENT JOB

The primary requirement for self-development is that the person improve himself in doing his present job. That is the base from which you move up and if your foundation is shaky you're not going to step very far without falling.

The world is changing so fast that a man must read and study continuously just to keep abreast of the changes. If you hope to stay even, much less advance, you must have a systematic plan of personal study and must take advantage of the various opportunities available to improve. And this is odd but true — you must enjoy doing it. It's no good if it strikes no spark.

But if your primary aim is to improve your performance in your present job you gain a desired by-product — you become capable of taking on greater responsibility as new opportunities arise.

FUNCTIONS OF MANAGEMENT

To be skillful, you must get skills.

To succeed as a manager the individual must study and learn the six basic functions of management: (1) plan, (2) organize, (3) motivate, (4) coordinate, (5) control, and (6) train.

These functions are studied continually by professional managers. Because of the scope of each one function, study is needed in depth and breadth. Good managers read books and trade magazines, they attend conferences and take special courses, they observe the practices of their colleagues — all aimed at improving their ability to perform the six basic functions of their profession. The greater the manager's ability in exercising these functions, the better will be his results. And the better the results, the better the job performance and the better position the manager holds.

Managers would be the first to agree that being a successful, progressing manager is hard work. If a person does not like responsibility, hard work, and long hours he would probably do better in other fields. Sometimes it is a good idea to remember this: The company needs good managers more than you need to be one.

VALUE OF EXPERIENCE

To gain proficiency in the management profession a person needs practical experience in performing the six basic management functions. Experience will show you the best way to apply these functions to your present job, as well as prepare you to perform future jobs. Professional managing, like professional athletics, requires practice for proficiency. And like professional medicine, it calls for continual study and up-dating.

You'll think the things you learn by experience only happen once, but some day you'll sit in a conference and suddenly find you can outline your project as well as the others. Or you may discover you can smooth a rough personal relation as smoothly as the psychologist described.

SOME PERSONAL TRAITS FOR SUCCESS

There are a number of personal traits which play a large part in determining a manager's success. K. S. Adams, board chairman of Phillips Petroleum Company, a few years ago presented to all employees his ideas of the personal traits which contribute to getting ahead. These traits are of special value to the manager who is striving for success, and are well worth quoting. Mr. Adams described them briefly as:

Determination — A burning desire to succeed — and a willingness to make personal sacrifices of time and talent to accomplish this.

Leadership — An ability to get along with people, show consideration for others, be a good listener, inspire confidence and respect, be just with criticism and quick with praise.

Self-Confidence — Confidence in one's own ability and judgment, readiness to accept responsibility and make decisions, capacity to profit by mistakes.

Analytical Ability — Simply, the type of mind which separates wheat from chaff and weighs facts, without losing sight of important details.

Originality — Ideas are the seeds of progress. One who comes up with new ideas and puts them into use is bound to progress.

What personal traits make good managers?

Self-expression — Ability to use the right words at the right time is essential.

Loyalty — A deep and abiding belief that one's company deserves his whole-hearted effort and support — a sense of pride, loyalty to products, management, owners and his associates, and respect for authority.

These are the qualities it takes. Do you have them? Or more to the point, can you get them? If you will try here are some guideposts:

1. *Develop yourself in your present job through study and extra effort — improve your present job performance.*
2. *Study the basic functions of management.*
3. *Apply these functions with determination and imagination.*
4. *Gain experience and recognition by ever-improving use of these functions.*
5. *Develop the personal traits which will contribute most to your success.*

"No one has a good market for bad merchandise." This slogan can be applied to management work and activities. Good efforts are merchandise that will find their market. Job knowledge and skilled use of management functions when applied with determination and good judgment lead to success in the management market.

Successful managers have professional skill and ability. This skill and ability is acquired through study and application. There is always room for the man who can get results — both short and long-range. Management has need for professional managers. The work is highly rewarding and satisfying. Are you ready to try it?

Test Your Managing Skill

1. Do you think of management as a profession?
2. Do you have a "management development program" to fit your own needs?
3. Is your primary goal self-development?
4. Do you have a systematic plan of personal study?
5. What are you doing to improve your ability to perform the six basic functions of management?
6. What are you doing to develop yourself in your present job?
7. Does a check list of your personal traits qualify you for management success?
8. Do you truly like the job of management?

For More Information Read:

[1]*Virgil K. Rowland, Improving Managerial Performance, Harper & Bros.*
[2]*Louis A. Allen, Management & Organization, McGraw & Hill.*
[3]*Library of Business Management (6 volumes), McGraw-Hill.*
[4]*Ralph Cordiner, New Frontiers for Professional Managers, McGraw-Hill.*
[5]*Koontz & O'Donnell, Principles of Management, McGraw-Hill.*

Quick Reference to Petroleum Operations

THIS IS THE FIRST TIME we've tried to pinpoint data at the end of the six-months period and some information has been difficult to obtain. In time, however, this half-year table should provide a good indicator of world trends.

Gas production figures are sketchy and no totals were attempted.

Communist countries have a fondness for percentages and totals hoped-for under the Five-Year Plans. Sometimes figures are only percentages of plans, so they are pretty hazy. One sure item is the tremendous soaring of natural gas utilization in the Soviet. Most figures released on Red China's oil production include synthetics. We believe the amount here is crude oil.

Reserve figures have not been completed but we expect to check with authorities on each one before the next publishing. This is not an estimate of world reserves so much as specific placement. Data on natural gas is very scarce.

We have tried to keep rigs limited to active rotary units. Workover and stratigraphic rigs and cable tools were eliminated where known.

This table will be published at intervals to aid in keeping up-to-date on Global Notebook countries.

WORLD-WIDE PETROLEUM OPERATIONS FIRST HALF OF 1959[1]

Geographic area	Active rotary rigs	Wells drilled	Production		Refining			Consumption incl. bunkers	Estimated proved reserves	
			Crude avg. b/d	Gas avg. mcf/d	No. plants	Crude cap. b/d 6/4/59	Runs avg. b/d[2]		Million bbl	Million cu ft
North America										
Alaska	8	7	650	—	—	—	—	15,000	—	—
Canada	165	1,217	490,000	1,250M	45	890,750	729,380	780,000	5,000	—
Hawaii	—	—	—	—	1	3,000	2,800	38,600	—	—
Mexico	110	220	280,000	720M	8	357,000	297,000	280,900	2,500	—
United States	2013	25,300	7,034,000	37,260M	298	9,803,000	8,474,000	9,748,900	30,536	254,100M
TOTAL N. America	2296	26,744	7,804,650	39,230M	352	11,053,750	9,503,180	10,862,500	—	—
Central America & Caribbean										
Bahama Islands	1	—	—	—	—	—	—	1,500	—	—
Barbados	1	—	—	—	—	—	—	800	—	—
British Honduras	2	2	—	—	—	—	—	400	—	—
Costa Rica	1	2	—	—	—	—	—	3,550	—	—
Cuba	5	15	538	—	6	88,400	70,000	90,000	—	—
Dominican Republic	1	1	—	—	—	—	—	6,500	—	—
French Islands[3]	3	—	—	—	—	—	—	4,323	—	—
Guatemala	3	1	—	—	—	—	—	8,000	—	—
Haiti	1	—	—	—	—	—	—	1,000	—	—
Honduras	2	1	—	—	—	—	—	3,000	—	—
Neth.-Antilles	—	—	—	—	2	725,000	700,000	192,500	—	—
Nicaragua	1	1	—	—	—	—	—	3,200	—	—
Panama	2	1	—	—	—	—	—	29,500	—	—
Puerto Rico	1	—	—	—	2	75,500	63,000	38,900	—	—
TOTAL C. A. & W. I.	24	22	538	—	10	888,900	833,000	383,173	—	—
South America										
Argentina	100	180	120,000	105,000	15	217,600	215,000	246,000	2,000	—
Bolivia	17	17	9,490	—	4	12,500	6,000	6,000	94	—
Brazil	46	101	57,212	33,049	8	161,000	144,534	222,421	250	—
Chile	5	16	16,800	164,000	2	20,700	23,000	48,000	65	—
Colombia	23	73	138,000	—	5	73,900	66,500	56,000	750	—
Ecuador	7	4	8,000	—	3	6,300	6,410	10,000	24	—
Paraguay	1	1	—	—	—	—	—	2,000	—	—
Peru	9	10	46,000	112,000	3	46,800	44,215	41,600	325	—
Trinidad	0	127	108,760	241,000	3	186,000	165,000	38,000	425	—
Uruguay	31	2	—	—	1	27,000	21,700	25,500	—	—
Venezuela	52	400	2,818,000	3,000M[4]	16	830,000	820,000	187,200	17,177	34,000
TOTAL S. America	291	928	3,322,262	2,155M	60	1,581,800	1,512,359	882,721	—	—
Western Europe										
Austria	19	36	48,540	84	9	46,240	36,443	41,350	238	—
Belgium-Luxembourg	—	—	—	—	8	155,000	135,000	145,000	—	—
Denmark	1	1	—	—	2	4,250	3,541	88,000	—	—
Finland	—	—	—	—	1	25,000	20,700	34,600	—	—
France	44	116	28,300	103,590	15	763,200	509,900	504,000	200	—
Germany (West)	95	270	88,000	33,700	27	590,000	395,000	466,000	425	—
Greece	—	—	—	—	1	36,000	35,000	37,500	—	—
Ireland	—	—	—	—	1	40,000[4]	—	25,000	—	—
Italy (Sicily)	50	49	32,320[5]	550,000	35	720,000	640,000	378,000	300	—
Malta	1	—	—	—	—	—	—	3,439	—	—
Netherlands	4	8	33,402	—	2	349,000	330,000	240,900	200	—
Norway	—	—	—	—	1	2,500	1,600	65,000	—	—
Portugal	1	1	—	—	1	26,000	22,400	24,000	—	—
Spain	8	5	—	—	3	150,000	100,000	100,000	—	—
Sweden	—	—	—	—	4	52,000	43,000	211,500	—	—
Switzerland	1	—	—	—	—	—	—	60,000	—	—
United Kingdom	6	18	1,650	—	16	920,000	746,000	730,000	6	—
Yugoslavia	16	23	10,300	4,400	3	24,500	22,100	21,000	40	—
TOTAL W. Europe	245	528	242,512	691,774	129	3,903,690	3,040,684	3,175,289	—	—

[1] Based on data from government authorities, U. S. Bureau of Mines, API, Petroleum Press Service and Communist publications.

[2] Bbl/calendar day.

[3] Martinique,, Guadeloupe, etc., in West Indies; also New Caledonia, etc.

WORLD-WIDE PETROLEUM OPERATIONS FIRST HALF OF 1959[1] — (Continued)

Geographic area	Active rotary rigs	Wells drilled	Production		Refining			Consumption incl. bunkers	Estimated proved reserves	
			Crude avg. b/d	Gas avg. mcf/d	No. plants	Crude cap. b/d 6/4/59	Runs avg. b/d[2]		Million bbl	Million cu ft
Africa										
Algeria	40	56	16,000	1,000	—	—	—	26,500	4,100	2,800
Angola	5	6	2,000	—	1	2,600	2,000	3,560	25	—
Belgian Congo	1	1	—	—	—	—	—	10,500	—	—
Cameroons	1	1	—	—	—	—	—	2,000	—	—
Egypt	8	16	59,700	—	3	90,000	74,200	105,000	500	—
Fr. Equatorial Africa[10]	14	15	14,775	—	—	—	—	3,975	59	1,200
Fr. West Africa	4	5	—	3,500	—	—	—	12,000	—	—
Ghana	1	—	—	—	—	—	—	7,500	—	—
Kenya	1	1	—	—	—	—	—	15,950	—	—
Libya	26	12	—	—	—	—	—	3,000	1,500	—
Madagascar	2	3	—	—	—	—	—	2,500	—	—
Morocco	4	12	1,896	741	1	4,100	4,040	20,000	10	20,000
Mozambique	1	1	—	—	—	—	—	500	—	—
Nigeria	9	8	7,809	—	—	—	—	11,000	80	—
Portuguese Guinea	1	1	—	—	—	—	—	100	—	—
Senegal	3	2	—	—	—	—	—	11,075	—	—
Somaliland (Br.)	2	2	—	—	—	—	—	4,400	—	—
Somaliland (It.)	1	1	—	—	—	—	—	2,300	—	—
Tanganyika	2	2	—	—	—	—	—	6,500	—	—
Tunisia	2	2	—	637	—	—	—	8,900	—	—
Union of S. Africa	—	—	—	—	1	24,300	22,300	95,400	—	—
TOTAL Africa	128	147	102,180	5,878	6	121,000	102,540	352,660	—	—
Middle East										
Aden	—	—	—	—	1	120,000	78,000	59,000[3]	—	—
Afghanistan	2	1	—	—	—	—	—	1,000	—	—
Bahrain Island	2	8	40,730	—	1	186,500	193,000	15,000	225	—
Iran	15	7	904,000	—	3	412,000	316,000	55,000	35,000	—
Iraq	10	6	805,381	—	4	55,830	42,000	30,000	25,000	—
Israel	4	3	2,700	5,000	1	85,000	27,054	33,399	40	—
Jordan	1	—	—	—	—	—	—	3,300	—	—
Kuwait	6	20	1,399,439	—	1	190,000	135,500	48,000	62,000	—
Lebanon	—	—	—	—	1	23,500	18,000	20,000	—	—
Muscat-Oman (Dhofar)	1	11	—	—	—	—	—	100	—	—
Neutral Zone	4	11	110,000	—	1	50,000	32,000	2,500	6,500	—
Qatar	3	3	171,812	—	1	600	600	2,000	2,500	—
Saudi Arabia	4	12	1,075,245	—	1	189,000	173,786	25,000	50,000	—
Syria	3	3	—	—	1	15,000[4]	—	15,000	—	—
Trucial Coast	2	1	—	—	—	—	—	500	—	—
Turkey	14	11	6,600	—	1	6,250	5,500	31,665	70	—
TOTAL Middle East	71	97	4,515,907	5,000	17	1,333,680	1,021,440	346,464	—	—
Far East & Oceania										
Australia	6	6	—	—	7	220,000	198,000	202,000	—	—
Borneo (Br.)	6	8	112,000	—	1	45,300	44,000	7,500	500	—
Burma	7	12	9,600	—	2	8,500	7,800	8,000	43	—
China (Formosa)	7	5	34	2,445	1	24,700	20,300	13,900	31	—
India	7	7	9,000	—	4	104,500	100,000	160,000	500	—
Indonesia	30	32	336,000	76,000	5	247,800	232,600	98,200	500	—
Japan	20	140	7,272	46,422	23	538,308	347,366	310,839	28	15,000
New Guinea (Neth)	2	—	4,371	—	—	—	—	1,000	25	—
New Zealand	2	1	18	—	1	60	17	32,000	1	—
Pakistan	4	5	5,800	36,878	1	7,500	6,800	39,000	16	—
Papua & Br. New Guinea	2	2	—	—	—	—	—	2,000	25	—
Philippines	3	10	—	—	1	25,000	25,118	46,804	—	—
Thailand (Siam)	2	5	—	—	1	1,000[4]	—	25,000	—	—
Timor	1	1	—	—	—	—	—	800	—	—
TOTAL Far East & Oceania	99	234	484,095	161,745	47	1,222,668	982,001	947,043	—	—
TOTALS Free World	3160	28,710	16,477,644	—	621	20,055,488	16,995,204	17,249,850[5]	—	—
Communist Block										
Albania	16	—	8,500	—	2	6,000	6,000	5,000	—	—
Bulgaria	3	—	4,600	—	1	2,500	1,500	14,000	—	—
China (Red)	60	—	28,000	—	10	50,000	45,000	80,000	225[7]	—
Czechoslovakia	3	—	2,200	—	4	28,000	25,000	35,000	10	—
Germany (East)	3	—	400	—	5	35,000	30,000	40,000	1	—
Hungary	30	—	17,000	53,000	5	37,000	35,000	39,000	175	—
Korea (North)	2	—	—	—	1	5,000	3,000	10,000	4	—
Poland	8	—	3,360	37,000	5	18,000	16,500	44,000	10	—
Romania	54	—	228,000	503,000	16	240,000	200,000	110,000	1,200	—
USSR	850	—	2,450,000	14,250M	81	2,400,000	2,100,000	2,000,000	58,000	120,000M[8]
TOTAL Communist Block	1029	—	2,732,060	14,843M	130	2,821,500	2,462,000	2,477,000	—	—
WORLD TOTALS	4189	—	19,209,704	—	751	22,876,988	19,457,204	19,446,850	—	—

[4] Was not onstream in first half of 1959.
[5] Sicily accounts for 30,420 b/d production.
[6] This amount produced; only ⅛ sold.
[7] Chinese Communist estimate 14.5 billion bbl.
[8] Mostly bunkers.
[9] This includes 300,000 b/d for areas not listed, such as Jamaica, Ceylon, Sudan, etc.
[10] Covers Gabon, Moyen Congo, etc.

Planning
Organizing
Controlling } Stressed in Executive Course

University of Pennsylvania's Wharton School opens its 11th annual conference in June . . . limited in size, intensive in study

John R. Abersold

THE WHARTON SCHOOL of Finance and Commerce, University of Pennsylvania is conducting its eleventh annual Executive Conference on Administrative Policies and Problems. This conference will be held for a two-week period beginning June 20, 1960. It is an intensive program for executives in or being groomed for top level administrative positions.

The program on Administrative Policies and Problems is designed to develop breadth in managerial thinking rather than to investigate practices and techniques. The program focuses attention on three major areas: (1) external environment in which business decisions are made, (2) internal environment of decision making, and (3) principles of effective administration.

In recent years industrial leaders have come to recognize that an awareness of business, government, and social environment is extremely important. Executives should have a greater appreciation of such areas as monetary and fiscal policy, impact of law on business enterprise, increasing importance of foreign trade, role of government in labor-management relations, and social responsibilities of business.

The business executive must also develop an understanding of the firm as a total entity. Often business executives become too narrowly specialized and lose sight of the impact of their decisions on other functional areas of the organization.

Finally, the business executive is expected to be an accomplished administrator. The program therefore focuses attention upon the basic functions of administration, planning, organizing, and control. It is felt that executives should have a greater appreciation of the planning process, the role of forecasting, and the importance of research. Moreover, they must understand the implications involved in the organizing process, development of executive capacity, communications, line and staff relations, and use of committees. Need for assuring that widespread operations of the business conform to basic policies has called for many new control devices.

Conferees at Wharton School take a coffee break.

Experience in conducting 10 prior Executive Conferences has demonstrated that the opportunity for executives from a number of companies in varied industries to exchange ideas and talk over their experiences is of great importance. In consequence, the objectives of this intensive program has been attained by the use of a combination of methods of instruction, each of which is designed to assure the maximum of participation in discussion by each conferee. This is accomplished by the use of a series of discussion sessions, the medium of panel sessions, and the utilization of problem solving — often referred to as the case method. The Conference faculty is drawn from industry, labor, government, the graduate division of the Wharton School and from other educational institutions.

The sessions are held in an air-conditioned and well appointed conference room in the new Wharton School building, Dietrich Hall. The conferees are housed in three fraternity houses each within a block from Dietrich Hall. Each conferee occupies a room by himself. All meals are served in the Phi Kappa Sigma fraternity house, which is headquarters for the conference.

In order that a concentrated conference may not subject conferees to "mental indigestion" from attending sessions continuously, appropriate recreational opportunities are provided without extra charge. One afternoon during each week is set aside for golf, swimming, or attendance at a major league baseball game.

An enrollment fee of $750 covers all sessions of the conference, as well as living and recreational expenses.

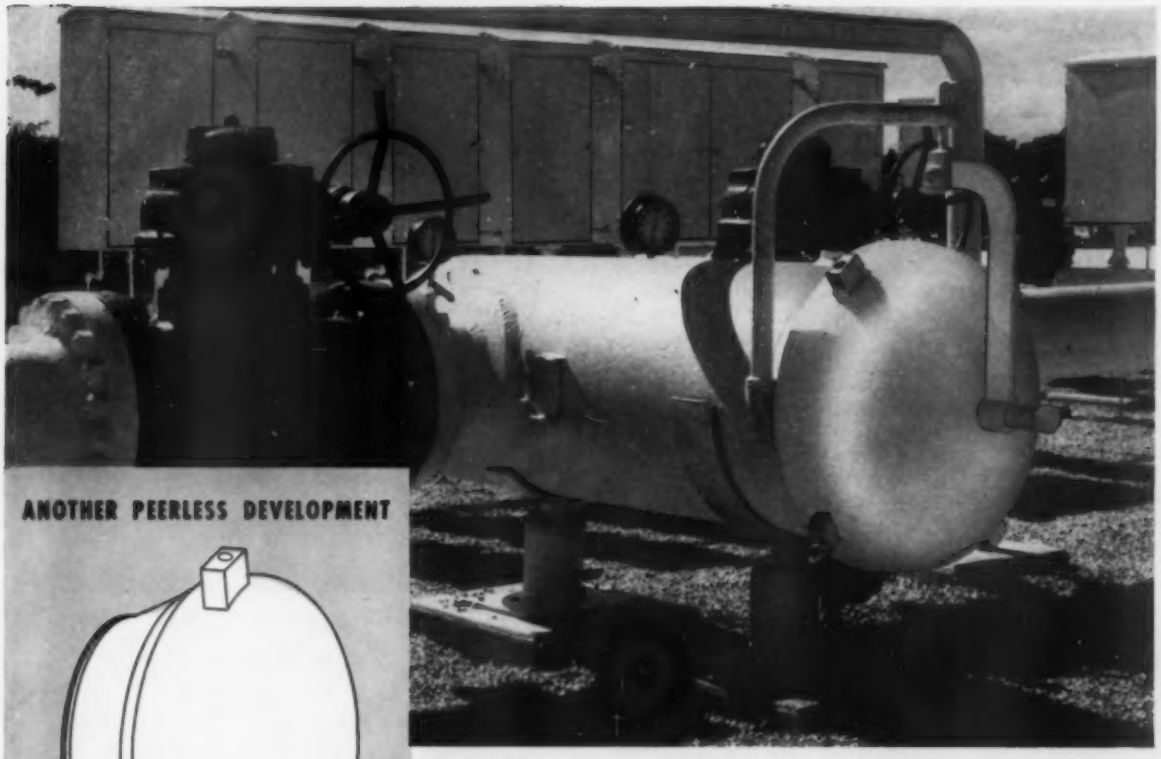
The conference is limited to 30 male executive personnel who have demonstrated to top management of their company that they possess the potential for unlimited advancement.

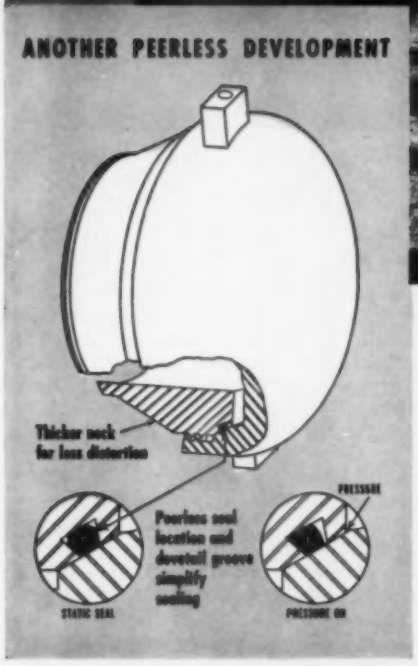
Experience has demonstrated that a conference of this type is enriched by a wide diversification of interests of conferees. Likewise, diversification of companies and industries represented around the conference table not only stimulates discussion, but brings forth a greater wealth of ideas and points of view. The average age of conferees attending prior conferences is 43 and the age range from the middle thirties to the middle fifties. Applicants for admission must be nominated by top management of their companies and then be screened by the Admissions Committee of the Conference.

Enrollment in the conference will close on May 1, 1960 and applicants will be notified of the action taken not later than May 10, 1960.

Copies of the program for the 1960 Conference as well as application forms may be obtained from Dr. John R. Abersold, Director, Executive Conference on Administrative Policies and Problems, Wharton School of Finance and Commerce, University of Pennsylvania, Philadelphia 4. ★ ★ ★

New Peerless O-Ring Closure Design assures fast, tight seals at low cost





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Petroleum Profile

ON THE MORNING of February 13, 1947, a hotel page boy in Bogota, Colombia, ran up to a vacationing Canadian guest from Toronto and handed him one of the most jubilant telegrams ever sent about the oil industry in Canada. The guest was John Rigsby White, now president of Canada's largest oil company, Imperial Oil Limited. The message read: "We've got Leduc No. 1 and this time it isn't water."

White, then a company director, promptly checked out and boarded the first plane home. Three short years later, he and his colleagues had the first barrels of prairie oil streaming east by pipeline from Alberta to the Great Lakes.

This feat was one of the big chapters in Canadian industrial development and a paramount example of large scale team planning. Before the historic Leduc find, 90 percent of Canada's crude oil had to be imported. Today over 70 percent of the nation's greatly-expanded needs comes from domestic fields, and Imperial (an affiliate of Jersey Standard), remains the largest producing company in the country.

When the big strike was made, White was plunged into a vital planning and coordinating role. Over a billion dollars in cash had to be raised, refineries built and pipelines laid to get the oil moving. White immediately backed the sale of two substantial Imperial subsidiaries to raise money and he had a big hand in charting other details of the development. An old wartime refinery at Whitehorse, in the Yukon, was moved piecemeal down the Alaska highway by truck and then by flatcar to Edmonton where it was reassembled — one of the biggest industrial moving operations ever undertaken in Canada. As derricks began dotting the prairie basin, an entire new refinery was built at Winnipeg.

Another essential was a crude oil line to get the oil east to the industrial heart of the country. Jack White was one of Imperial's chief planners when the company provided the initiative to build a 1200-mile trunk line from Edmonton to Superior, Wisconsin. Later the line was extended to Sarnia, Ontario, and then to Toronto. Today it is the longest crude oil pipeline in the world.

The strange thing is that it is quite by chance that Jack White ever came face to face with Imperial.

Born in London, Ontario — which coincidentally is also Imperial's birthplace — White was educated in local public and high schools and spent a couple of years studying chemistry at the University of Western Ontario. Then he moved to Toronto to complete his studies in mechanical engineering.

A tall, rangy, raw-boned young fellow, he was a lineman on the University of Toronto football squad where opponents got to know him as a 200-pound hardrock with a deceivingly light step and a bone-crunching block. He was also known to play a swift game of tennis and squash.

On graduation, Jack White took a job with a steel firm in London, Ontario — until the depression put the business on the skids and landed him on the job-hunting market. By chance he approached Imperial and the future president went to work as junior draftsman in the engineering department of the Sarnia plant. The year was 1933. Jack White was 25 years old and only just married.

After a year of huddling over the drafting board he was put on the design and testing of cracking coils. Four years later he was picked to spend a year in New York to get himself acquainted with the business side of the oil industry — long-range planning of capital, financial forecasting, and consulting work related to crude oil uses and values. The next year he was sent to Venezuela for an intensive six-year study of the operational side of the industry.

JOHN RIGSBY WHITE
President
Imperial Oil Limited

It was a busy and productive six years. White immediately set about learning Spanish, developed a connoisseur's taste for bullfighting and Latin-American music, and rose to be vice president of Standard of Venezuela. So conscientiously did he take his language study that when entertaining some Latin-American officials fifteen years later, he was able to spend the evening chatting with them in Spanish — much to their delight.

Back in Canada, White rejoined Imperial Oil as economic coordinator in 1944. A year later he was elected a director and the same year became a vice president. In 1950 he was chosen executive vice president.

He was 45 when he became president in 1953 — one of the youngest presidents of any coast-to-coast industry in the country.

An avid golfer (he shoots in the high 90's) and bridge player, White manages to sandwich these activities between tight schedules of board meetings, conferences and frequent speech-making dates and twice-a-year visits to the western oil fields. Last year he logged 44,000 miles by air in 67 different trips. He heads for his cottage on Lake Muskoka whenever he can get away to spend a quiet weekend with his wife, son and two daughters and indulge his fondness for sailing.

In 1951 the Toronto Engineering Alumni Association paid tribute to Jack White's administrative ability and leadership by awarding him its highest honor, a medal presented only once in three years . . . not for any isolated achievement in engineering but for demonstrated ability in coordination and teamwork. Significantly perhaps, the award was made at the end of four of the most important years in the history of Canada.

Good Wells Make Good News

A Report on Wells That Have Been Improved with Abrasijet

February, 1960

Abrasijet* is a new Dowell-developed service that uses high-velocity streams of fluid and abrasive particles, usually sand. The abrasive fluid is jetted against the casing or the hole wall, and has been extremely successful at both perforating and formation cleaning. Here are some results from wells where Abrasijet has been used.

- **Mesa County, Colorado** (Old Gas Well) This well was drilled in 1955 but had been plugged and abandoned. It was cleaned out and pipe was set. Abrasijet was used to perforate into the Morrison sand at a single level — 4073 feet. 6000 gallons of fluid carrying 6000 pounds of sand were jetted. Next, the well was fractured; it then potentialled 2400 mcfd. Other wells in the field usually potential around 500 mcfd.

- **Harper County, Kansas** (New Oil Well) An attempt was made to complete this well with conventional perforating through 4½-inch casing. Formation was the Mississippi Chat at about 4464 feet. After perforating, acid could not be pumped into the formation at 3200 psi. Then Abrasijet was used to perforate, and zone was treated with Mud Acid at 3.7 bpm and 1550 psi. After clean-up, well started flowing 12 bopd without fracturing.

- **Wise County, North Texas** (New Oil Well) This well was to be completed into the conglomerate. Abrasijet was selected to perforate at 5707 feet. Well was fractured down the annulus on the same well set-up. Treating pressures were lower than on offset wells. One month later production had stabilized at 135 bopd on a 13/64-inch choke. This production was 20 to 30 bopd better than from similar wells in the area. In addition, the operator saved over $600 in completion costs.

- **Alberta, Canada** (New Oil Well) Casing was set for this open hole completion at 8680 feet in an 8785 foot hole. The Mississippian was logged between 8705 and 8735 feet. Log indicated only three feet of "good" pay between 8717 and 8720 feet. Abrasijet was used to clean the hole wall. 25 barrels of acid (without sand) were jetted. The formation was then squeezed with 3000 gallons Dowell inhibited acid with a silicate control agent added. After clean-up, the well tested 220 bopd — operator felt this an excellent well, considering the thin pay zone.

Use Abrasijet for better completions, or better workovers of problem wells. For service or detailed information, contact the Dowell office or station nearest you. There are more than 150 locations in the United States, Canada, Venezuela and Argentina. Dowell, Tulsa 1, Oklahoma.

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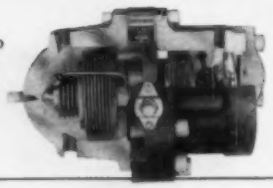

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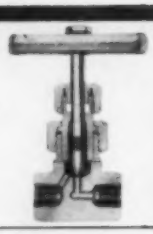

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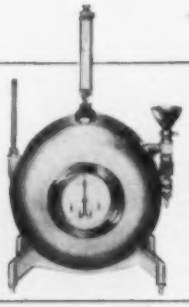

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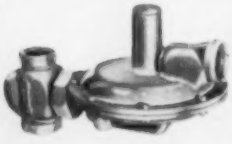

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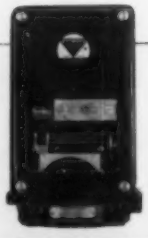

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THE CONFERENCE TABLE

The wise man doesn't expect to find life worth living; he makes it that way. — ANON.

Bibliography Draws Interest

Several letters have come in about the article "Suspense! Petroleum Industry History," which listed some books to read about the industry's past. Here is one letter:

"... regarding your article on historical books relating to the petroleum industry, I have spotted a couple that we missed and am embarrassed to note that I sent you a reference to the wrong Giddens book. It was my intention to send a recommendation for his Pennsylvania Petroleum 1750-1872," (the same book recommended by Jurgen Raymond).

"The Beginnings ... in 1941 contains many of the same letters and documents but it stops on November 25, 1859 and contains only bibliographical references to many of the items that appear in Pennsylvania Petroleum 1750-1872, published in 1947." Paul S. Allen, Librarian, Standard Oil Company (N. J.).

The two books are similar and it was well to have both mentioned.

Mrs. M. D. Minard, Shell librarian, suggested the scholarly histories of several major companies be listed ... that they were great contributions to oil history. We agree.

There are two bibliographies of the industry — not only history — that should be named: (1) Robert E. Hardwicke, Sr., Petroleum Bibliography, University of Texas, 1937, and (2) De Golyer and Vance, Bibliography of Petroleum and Natural Gas, University of Texas.

Communism possesses a language which every people can understand. It's elements are hunger, envy, and death ... — Heine

The Energy Base

The term "resource base," as used by Bruce Netschert, of Resources for the Future (The Ford Foundation), is derived from a concept he developed in seeking to measure the availability of oil and gas in the United States through 1975.

Hitherto, estimates of petroleum supplies have been based on what is commonly called "proved reserves." That is industry's shorthand for "proved recoverable reserves" — which is to say supplies that are definitely known and that feasibly can be extracted at current costs with current technological processes. At the end of 1958 proved reserves of oil in the United States were 30 billion bbl, against an annual production of 2.4 billion bbl. This has given rise to dire predictions as to future domestic scarcities and consequent increasing demands upon imports.

The Netschert concept makes it possible to place a quantitative estimate on the whole of a particular resource provided by the environment of a given area. Of oil, for instance, it is generally believed that only one-third of the oil in the earth's crust is recoverable by current methods in this country. Accordingly, industry's estimate of total future supply (which ranges between 86 and 240 billion bbl, depending upon the estimator's methods and cast of mind) may be multiplied by 3 to give an assumed resource base.

Netschert comes up with 500 billion bbl as his resource base for oil in the United States, of which 30 billion are "proved reserves" and 208 billion are known but as yet uneconomic to produce. Between the limits of "reserves" (30 billion) and the "resource base" (500 billion) there is a middle ground for which he uses the term "resources." The resources consist of that portion of the resource base (including reserves) which seems likely to become available given certain technological and economic conditions. For example, one may wish to estimate the oil resources that would obtain at twice present costs. Such a quantity would include a portion of the 208 billion bbl noted above (i.e., whatever it is estimated could be recovered at such costs) plus the quantity of as yet undiscovered oil which it is estimated would be discovered and produced under such cost conditions.

Applying this formula to the domestic availability of crude oil in the United States in 1975, Netschert reaches the reassuring conclusion that, with no appreciable increase in constant dollar costs, around 6 billion bbl of oil could be available. Of this, 4 billion bbl could be produced through primary recovery (a 57 percent increase over the 1958 level of production); the remaining 2 billion could be produced through secondary recovery.

Editorial Integrity

Joe B. Woods, president of The Petroleum Engineer Publishing Company, came in our office the other day and pointing to a clipping he had, said:

"This particular thing will never happen to our publications." Actually he was only reaffirming his often taken stand that the editorial department must be independent of the business departments.

The item was about Ben Hibbs, editor of the *Saturday Evening Post*, who told in an address at the University of Kansas why he thought *Collier's* folded. He said:

"During the last ten years of their existence, as financial troubles deepened, the *(Collier's)* editors were given less and less freedom of action. Someone from the business office was always looking over their shoulders. Things often were done editorially solely to attract advertising — always a vain procedure and in the end usually a fatal mistake.

"During the fifteen years from the day I became editor of the *Post* until the death of *Collier's*, that once great magazine had six editors-in-chief. I knew all of them except the last one. There were at least two of them who were able men and who probably could have made a go of it if they had been given the right to do their best, without interference from the top. They weren't. The business office ruled, and change after change was made in policy and personnel — too often for business reasons alone. It didn't work.

"I am fully aware that it is bad taste to speak critically about the dear departed, but in this case I don't apologize. It is one of the tragic stories of publishing, and it should be known. The cornerstone of editorial independence is just as important as it has always been."

There is no doubt there are times an advertiser can bring pressure that hurts. We once owned a newspaper and had to oppose an advertiser editorially over a city council matter. We stuck to what we thought was right, but we lost that advertiser for all time. We learned then that editorial integrity is not cheap. But lack of editorial principle is the most expensive item in the publishing business.

Analyze Your Job

In the "How to be a Manager" series two chapters are scheduled on understanding your job. One is the value of studying what is expected of you and determining whether this job of yours contributes to your career. The other deals with understanding the position ahead of yours.

To do either one the American Management Association Research Study, "Defining The Manager's Job" by C. L. Bennet, (American Management Association, 1515 Broadway, Times Square, New York 36, New York. Price $6 to members; $9 to non-members) will be of specific value. A survey among 140 companies brought out descriptions of managerial positions, including that of president. One illustration is Standard of California's "Management Guide." These guides, according to the booklet, "not only expound the intangible aspects of positions and their interlacing relationships, but they also serve to inspire the occupants of the positions with which they deal to set a goal of achievement and stir the individual to pattern the fulfillment of this position to the ideal as expressed in the guide."

Most companies gave as one use of position descriptions: "To clarify relationships between jobs, avoiding overlaps and gaps in responsibility." Other reasons given most frequently were: (1) Just basis for salary structure; (2) to help managers acquire greater understanding of present jobs; (3) to evaluate individual's performance of their jobs.

✔ *Cunning is the ape of wisdom . . .* — Locke

Buy a Mink Coat

A replica of a dollar bill is an interesting mailing piece that Shamrock Oil Company has produced. The dollar bill, with a picture of George Washington and an oil worker's steel helmet in the center, tells the story that 40 cents out of every dollar paid for gasoline goes to the state and federal government for taxes. It further illustrates the fact that if the same dollar had been spent on a mink coat, the tax would have been only 10 cents.

One Company's Creed

An ideal unstated is one unformed. Each year more companies put their purposes and goals into words. These are creeds you can hold to and work by. In its annual report last year, Standard of California published this declaration of principles:

We of Standard of California recognize that our business exists to serve the common good and that what we do is of broad interest to many people.

Our company's basic policy can be stated like this: To make products high in value to our *customers* at the lowest competitive prices that will enable us to keep faith with our *stockholders*. To support bold research and development programs for the benefit of the *general public*. To act with integrity as a conscientious member of the business community. And to deal fairly with our fellow *employees*.

We have full regard for every employee as an individual person. We believe that he should receive individual consideration, recognition and dignified treatment, and the stablest possible employment; receive a fair wage; be protected with safe working conditions; and be aided in protecting himself against those financial problems brought on by accidents, sickness, old age and death.

We practice corporate good citizenship and encourage our employees to take part in civic activities in their communities. We keep out of politics but believe it is our inherent right to take proper steps to safeguard our interests by presenting facts affecting us directly to the public and to legislative representatives.

In time of peace or war or threat of war, our first consideration is to our Nation's defense. Our military forces must have prior claim on our services and products and our fullest resources are dedicated to the common defense at all times.

The distinctive character of our company was shaped by men of good will and, with these principles as our guide, we shall continue to manage our affairs so as to reflect credit upon our company, our industry and our country.

✔ *Life often presents us with a choice of evils rather than of good . . .* — Colton

When to Retire

With more and more skilled Americans reaching the generally mandatory retirement age of 65, longevity is becoming a problem. For many, the sudden jolt from active to sedentary life can have serious consequences.

For this reason, the U.S. Department of Health, Education and Welfare is studying a new approach to the retirement problem. Basis of the plan is gradual retirement, starting at age 62 for a period up to five years. During this period, the work schedule would get shorter and less arduous with every year. This would be achieved by one of several methods (or two or more combined): Extending vacations each year; shortening the work week; increasingly shorter work days; shifting responsibility to younger people; transfer to less taxing duties.

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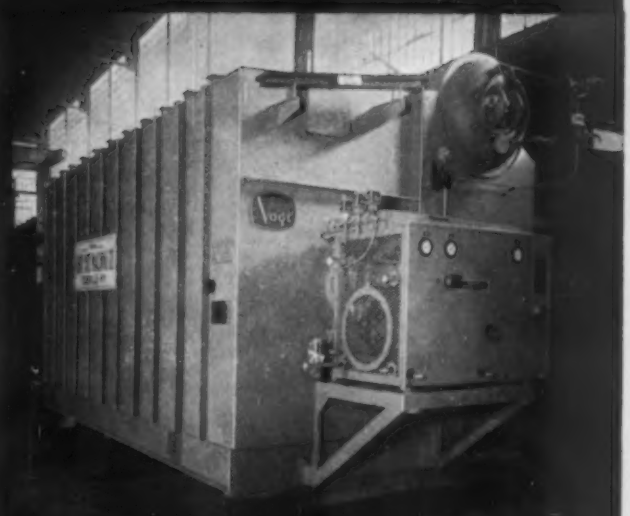

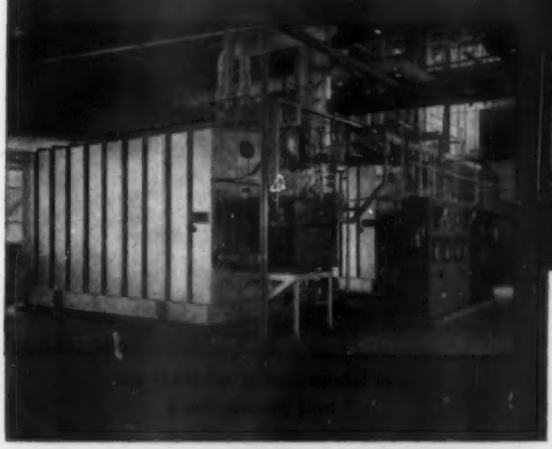

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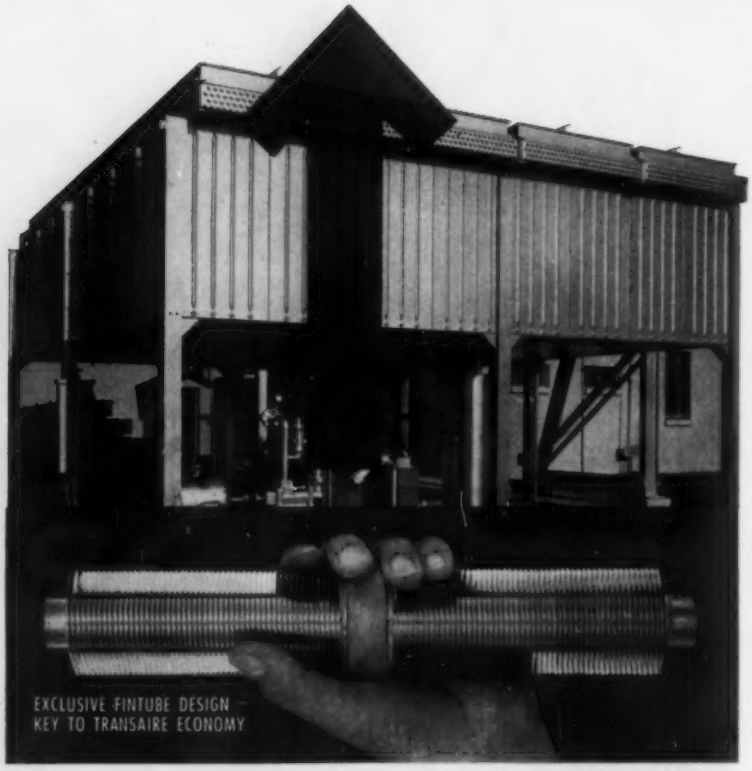

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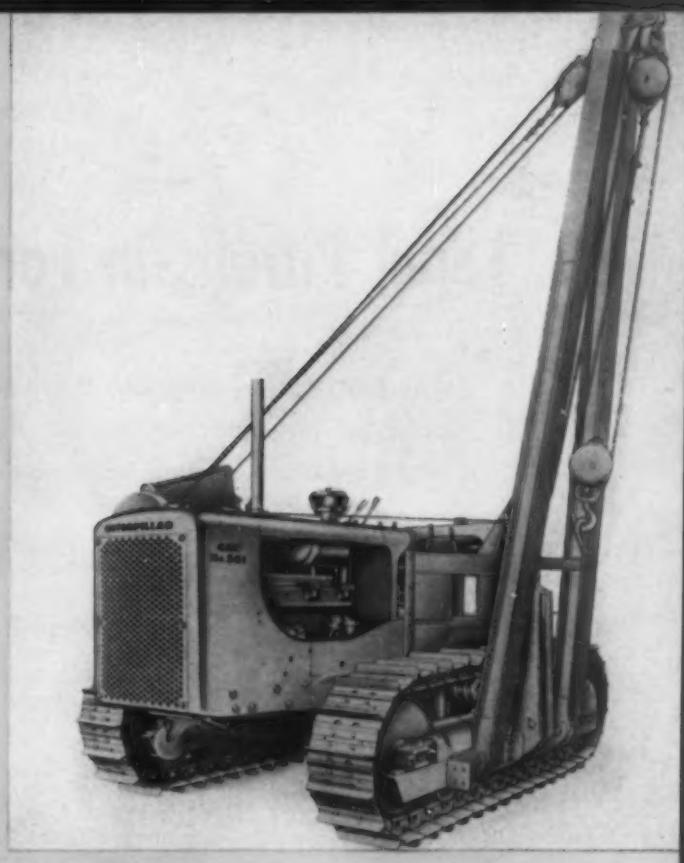
38,800-lb. lift with hydraulically adjustable 5,000-lb. counterweights (optional)—two other stationary counterweight arrangements available in 2,500-lb. and 3,500-lb. groups • 93 HP • Direct drive with exclusive Caterpillar oil clutch • Heavy 15' boom (12½' and 18' booms optional) • 3-speed lift, 1-speed lower winch transmission • Fast, convenient controls that are easy to reach and easy to operate with safety engineered into every motion • 10½" ground clearance • 74" gauge tracks • Heavy-duty lifetime lubricated undercarriage.



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These and many other features are listed briefly. Look them over. But for the full story, see your Caterpillar Dealer. Get the complete facts about the all-new No. 561 from him. Ask him to demonstrate. See for yourself how you can use it in your spread on a wide range of jobs.

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HEAVY-DUTY PIPELAYERS FOR THE HARD WORK

Legal Pitfalls in Foreign Operations

Check list for the company that operates overseas or plans to enter the international picture . . . Every country is different and the petroleum code is just a part of what you have to know

William A. Sackmann

IT SHOULD BE STATED that the subject "Overseas Oil — Legal Problems" is going to be discussed from the standpoint of this country boy operating from Findlay, Ohio. It is a broad subject and is analogous to telling a group of lawyers how to practice law in 30 minutes.

I have divided this subject into these stages:

1. **Investigation of investment climate of a country.**
2. **Concession or agreement stage.**
3. **Considerations needed to determine the corporate structure or organization structure for operations.**
4. **Exploration and exploitation stage.**
5. **Transportation stage.**
6. **Refining.**
7. **Marketing.**

Regardless of how big or how small a company may be, a decision still must be made on each new area or new country. So, large or small, legal problems must be faced which must start when the manager comes in and says, "What about 'Oilville'?" Now, often as not, the lawyer to whom this question is propounded gives a dignified response such as, "I haven't looked into the legal situation in Oilville for some time, but will give you my opinion sometime next week." As soon as the questioner leaves the lawyer's office, he quickly runs to his World Atlas, his revolving map and his medicine cabinet and, between aspirins, tries to locate Oilville on the map. Upon finally finding this great country that the geologist is sure has great possibilities for oil (because they heard at their geologic meeting that five other countries knew there was oil in Oilville), the lawyer then tries to evaluate the so-called investment climate from the legal point of view.

Burney Braly, formerly associate General Counsel of Continental Oil Company, now retired, in *The Petroleum Engineer* of February 1957, generally outlines the questions an oil company should answer before venturing abroad after geological information has indicated the area might be profitable from the geological standpoint. This list includes:

1. Is the country politically stable?
2. Are American citizens and companies welcome?
3. Do the statutes, laws, constitution or historical background permit aliens to have an interest and operate a concession in the country?
4. What are the tax laws of the country?
5. Are you able to remit your profits in dollars?

Is Nation Politically Stable?

Of the above listed points, political stability must encompass considerations as to matters governing imports, currency, and personal barriers applicable to foreigners. While studying the tax situation, the lawyer must of necessity weigh the United States tax situation along with the tax position of the company operating in the foreign country.

An example of how oil companies sometimes get caught in the middle is pointed up by the recent decision of the Supreme Court in New York County forbidding Aramco from inquiring into the religion of an applicant for a job. The Saudi Arabia Government prohibits the employment of a Jew in Saudi Arabia. Yet, to inquire into the religion of a job applicant is now prohibited by the New York Court.

Another example of laws which sometimes may be overlooked are those which deal with nationality of top employees. Even if a company may be allowed to operate in a country, the labor law or even the concession or petroleum law may require that the managing director, supervisor or other named managing officers must be of a certain nationality.

What Is the Tax Structure?

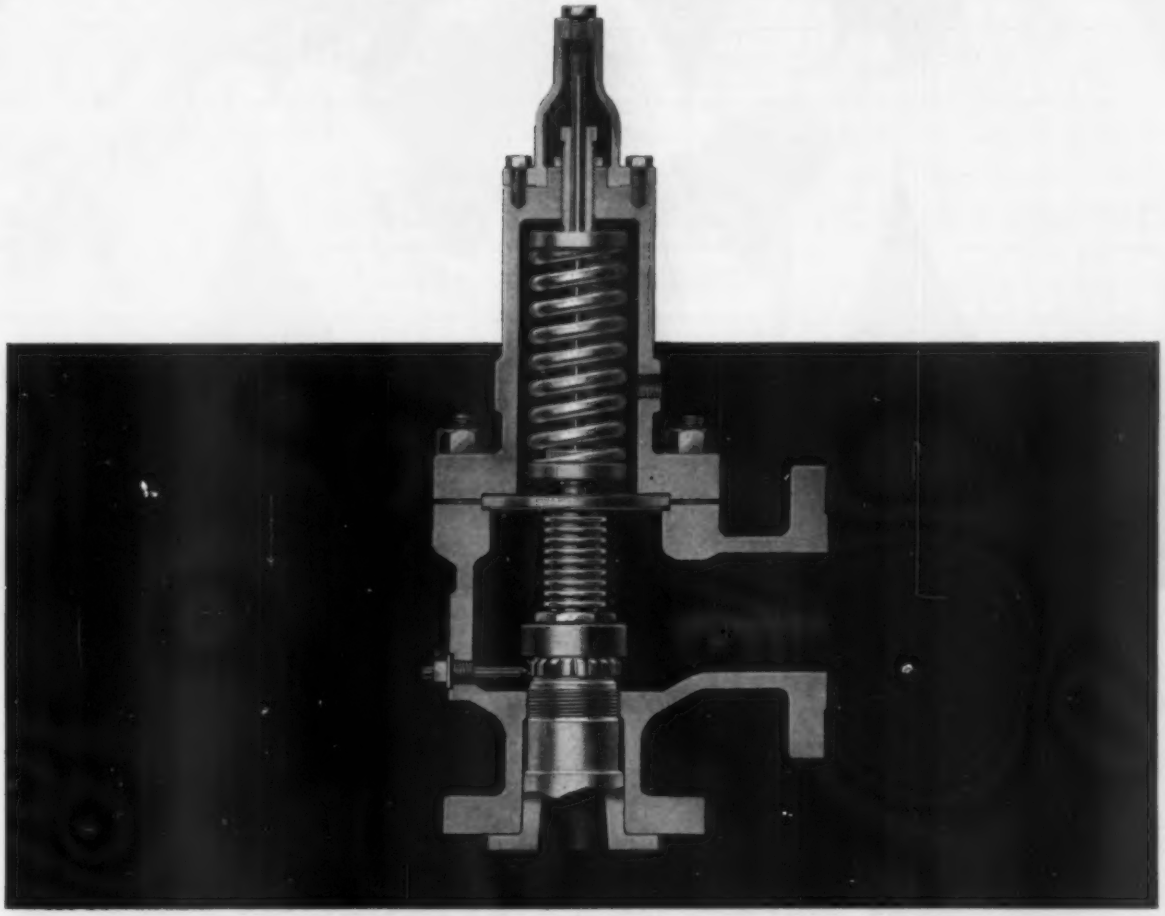
Another real pitfall is in checking the tax structure of a foreign country. Joseph L. Hull, Jr., general counsel for Seismograph Service in a paper given before the Eleventh Annual Conference of Accountants in 1957, stated: "The average American businessman considering for the first time an entry into commerce in a foreign country may well view the tax picture as a modern version of a chamber of horrors." He added, "Where businessmen in the past jokingly referred to going to Washington to be with their money, they have now found that their money has been sent abroad in the form of foreign aid."

Oil companies set up their foreign operations differently from other forms of business because of the interplay of United States taxes and foreign taxes, and because oil operations, at least in the initial stages of exploration, require large expenditures that a company wishes to write off as they go along. In addition, no real income from operations in a particular country usually results for at least five years or more. This is not, of course, true where the operation is in refining or retail marketing.

If management has decided that the investment climate is satisfactory, the next stage is the actual working out or

Mr. Sackmann is attorney for the foreign department of The Ohio Oil Company. This paper is a condensed version of a speech given before the Desk and Derrick national convention in San Antonio, Texas, October 3, 1959. His article, "Legal Systems — Key to International Oil Operations", was published in *The Petroleum Engineer*, June 1959, Page B-117.

Look into Lonergan Bellows Valves



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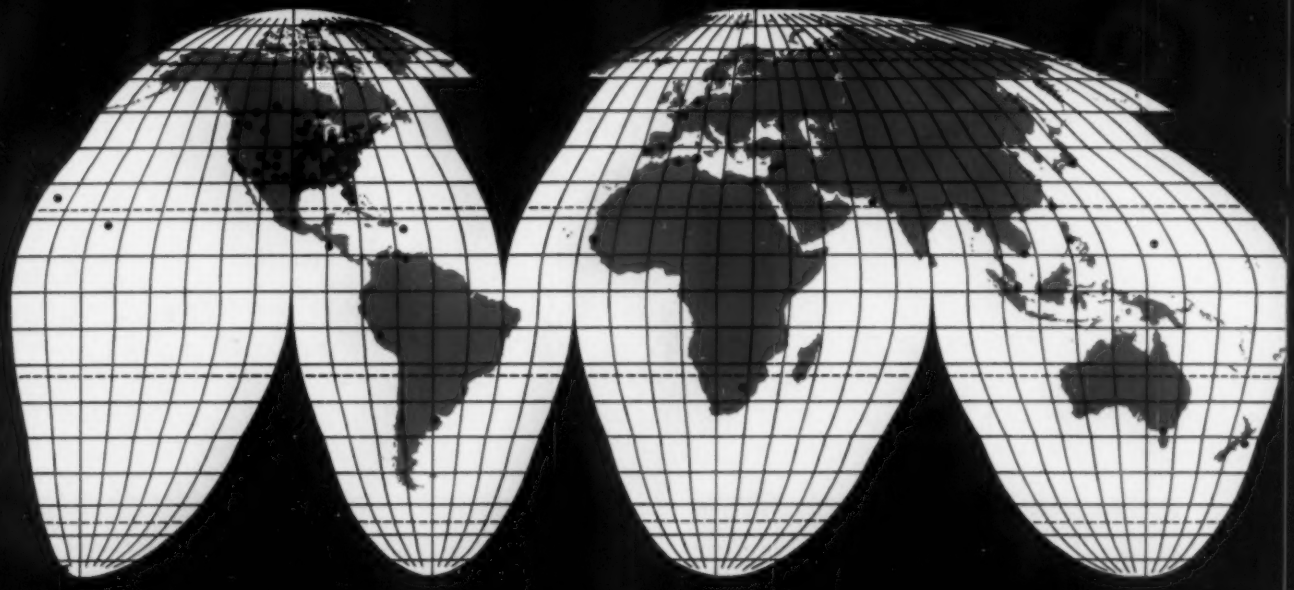

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acquisition of a right to search for, develop and transport petroleum in the country in question. In most countries, with the notable exception of the United States of America, petroleum resources underground are the property of the state. Sometimes the government attempts to develop its own resources but because of the speculative nature of oil search, governments are more and more opening their doors to foreign firms so that public funds can be invested in projects such as schools, hospitals, dams, and road programs.

Who Has Authority?

Negotiations are always different, and each creates its own little problems. Unless there is a petroleum law, the first problem confronting the negotiator or team of negotiators (which is often the case) is with whom in government should they be dealing. This really is not as simple as it might seem; as an example Mauritania, until recently a part of France, but which in 1958 voted to be independent, has allowed concessions to be negotiated, but who has the actual authority to grant the concession, and whether it should be also approved by its legislative body is quite a decision.

Argentina, by executive decree, named YPF as the one with whom agreements should be worked out for petroleum operations in that country. It is noted, however, that almost every agreement has also had a clause requiring a National Executive Decree or some other top official approval.

A concession provides for payments to the government in the form of royalty, profit split and rentals, provisions for assignment, depletion, right to refine, market and transport in the country, together with an obligation to spend a certain amount in work obligations, with specific provisions for surrender and, of course, the tax regime to be applied, and generally the necessary clauses pertaining to currency, repatriation of profits and other financial provisions. At each juncture of the concession negotiation, the lawyer or others negotiating the concession must strive to look in the future some 30 to 50 years and cover contingencies that might come up.

One of the largest problems of a negotiator in a foreign country is communication with his people in the states. Probably one of our biggest items on our hotel bill is long distance calls or cables. Remember, that secrecy is not necessarily a by-word of foreign countries — letters, cables and telephone calls have a habit of being opened or listened to. It's like peeking into your opponent's poker hand or bridge hand — one peek can mean a great deal when you are bargaining.

Corporate Structure Puzzles

When the concession has been worked out, the next thing confronting management and the lawyer is the corporate structure or organization method to be used in this foreign operation. Again, tax considerations must weigh heavily in this decision but also, other factors may require the structure even in the face of adverse tax considerations. In Algeria and France, for instance, participation of local capital is a requirement, and it is a consideration under the Petroleum Law of Iran and the new Petroleum Law of Spain.

Since a great number of foreign ventures are extremely expensive, companies which are competitive and independent in their United States activities tend to go together, to share the risk so-to-speak, in a foreign venture and at times a so-called "captive mine" type of corporate structure emerges. This is a company in which ownership of the stock is held by the participating companies, and this company then acts as the operator in the foreign country. Generally, the concession, permit or petroleum right is held in undivided shares by the participating companies, rather than by the captive mine company. In fact, all title to assets remains in the owner companies.

Almost every type of corporate entity is used in oil operations but that most generally used if permitted is a Delaware wholly-owned subsidiary of the parent company, with a registered branch in the foreign country. This subsidiary can take advantage of: (1) Western Hemisphere provisions of the tax law; (2) The company can be consolidated (by paying a 2 percent penalty) with the parent company; (3) foreign depletion allowance; (4) U. S. tax credit. Basically, all tax reasons. This, of course, is for exploration and exploitation operations. In addition, management should consider the following in choosing the proper corporate entity to be used in foreign operations:

1. Choose a corporate entity that does not subject the parent company to possible liabilities.

2. Registration laws make it very expensive to register a branch of parent company.

3. Social and labor laws in foreign country may conflict with policies of parent company. Also, labor laws sometimes provide for division of profits—much better it is the subsidiary's profits you are talking about than parent's.

4. Charter provisions of parent company may conflict with rights granted in foreign country (example, Spain).

Watch Those National Laws!

One problem, of course, for the lawyer is to have available the laws of the particular country. When oil companies first started activities in the United Kingdom of Libya after a forward-looking petroleum law was passed in April of 1955, I remember one provision was the requirement to register your company in the Company Registrar Office, with penalties stated for failure to do so. The law was on the books, but no office was set up to handle applications so for about a year of operations the oil companies filed with a Notary Public who, in turn, got a Chamber of Commerce registration number which was all we could do.

Sometimes legal problems arise over which the lawyer has little control, such as the application of the Arab Boycott. I remember we had jeeps made in Israel in Libya when enforcement of the Boycott took place, and were faced with obtaining parts for those already in Libya. Only temporary relief could be obtained and now English-made Landrovers are used instead of jeeps.

A rather recent event took place in our company's operations in Guatemala. We had purchased two C-82s, large cargo transport planes, to supply our Chinajá operation by air, including the flying in of the complete rig, casing and other materials and supplies. Once we had trouble and needed some new casing and drill pipe in a hurry. I was asked to get clearance to bring our C-82s into the United States to pick up the material and fly it back to Guatemala. But C-82s were not considered as air-worthy in the United States and the only way to get permission to fly these planes in the United States was to obtain a waiver on an emergency basis. Since all this happened on a week-end, it was not possible to obtain a waiver, so charter agreements were arranged with Pan American Airlines who airlifted the material to Guatemala.

Another rather unusual situation has been brought about in operations by the fact that the countries in North Africa had many mine fields left after World War II. This made it necessary for large mine crews to be hired to precede gravity, seismic and geological teams. In search for mine clearance equipment, it was found that the only way to get the equipment was by a lease arrangement and clearance from the U. S. Army. An agreement was entered into on a rental basis for 100 mine detectors, which we must return at the end of our use.

So You've Found Oil!

When oil is discovered, the legal problems really start to multiply. First, of course, comes the management decision as to how the oil will reach the potential market. Will it be transported by truck, rail or pipeline? Major problems have arisen where pipelines have been chosen, especially if the line must cross sovereign boundaries. The recent basis of pipeline payments from the Middle East, for instance, has been for the companies to share 50-50 with transit states the net profit of transporting by pipeline rather than via Persian Gulf. The division between transit countries generally settled on a ton-mile basis—which Lebanon has now rejected.

The concession agreement or petroleum law, generally speaking, grants transit rights within the country in which petroleum is discovered so that major pipelines problems come about when it is necessary to transport across sovereign state lines. For example, the French made an agreement with Tunisia to run the pipeline from the Edjélé area in Algeria to a loading area close to Gabes in Tunisia.

Another project being discussed where transit will be across several countries is a large pipeline through Iraq and Turkey to the Eastern Mediterranean at a probable cost in the neighborhood of one billion dollars. This may never come about because of recent events in Iraq.

The First Arab Petroleum Congress held in Cairo, Egypt, in April 1959, included in its final statement: "The Delegates also seized the opportunity to outline the importance they attach *to the execution of the Arab Pipelines Project*, the necessity of increasing refining capacity in the oil producing countries, the setting up of petrochemical industries, as well as institutes and centers necessary for the formation of national technicians, and their training to do all jobs and carry out the different operations connected with the petroleum activities . . ."

Refining and Marketing

In refining the concession often commits the concessionaire to refine a certain percentage of the crude oil in the country in question. As an example, companies applying for concessions in Venezuela in 1957 agreed to refine 15 percent of their crude oil production from said concessions. Most petroleum laws grant to a concessionaire the right to refine in the country, and often require the concessionaire to supply proportionally with other concession holders sufficient crude to satisfy local consumption. Refining problems are primarily the same for foreign operated refineries as domestic except that compliance with local laws, especially labor and social legislation, requires knowledge of applicable laws.

In marketing, which really should be broken down into two types, being (1) crude oil marketing and (2) refined products, the major problem comes about in determination of the corporate structure or structures and within this same problem and inter-related are the financial problems tied to currency convertibility and remittance of profits.

When a company enters the retail or wholesale market in refined or crude products in a foreign venture, a corporation often is set up under the laws of the particular country, either wholly owned or if deemed advisable, with local participation. I was told at a rather recent conference I attended that Mobil had some 120 separate subsidiaries for marketing activities. Necessarily, the local management must handle legal matters, and seldom does the lawyer in the United States have to be involved unless there is some interplay between considerations of United States law and the foreign law. The most important of these which the U. S. attorney must be ever aware of are the tax and anti-trust laws. Agreements entered into in the foreign country can be just as much in violation of the United States anti-trust laws as if entered into in the United States and every move taken in the foreign country can also have tax consequences in the United States.

As the treasurer of your company can verify, banking and currency problems will be coming up in our foreign ventures. So long as we were only paying out dollars, there are few problems, but once we start receiving francs, marks, pounds and pesos, currency and convertibility problems will become a challenge and must be faced by management and, to a more minor extent, the lawyer whose role will be in approving from the legal point of view financial transactions, swaps, hedging deals, and so forth.

Of necessity, this discussion on overseas-oil legal problems has had to be of a general character as books have been written about each phase of the subjects which are covered in this paper. Barely touched upon, but of equal and of great magnitude and importance are the subjects of accounting in the foreign field and personnel problems and policies.

In addition, insurance, purchasing and transportation problems come up daily and require competent personnel to adequately handle the multitude of papers needed to service the overseas operation. Personnel from the accounting, personnel, insurance, purchasing and transportation departments of any oil company seek advice and assistance from the legal advisor. This, plus his other duties more thoroughly covered in this paper, are what makes the job of a lawyer in the foreign field such a pleasure. ★ ★ ★

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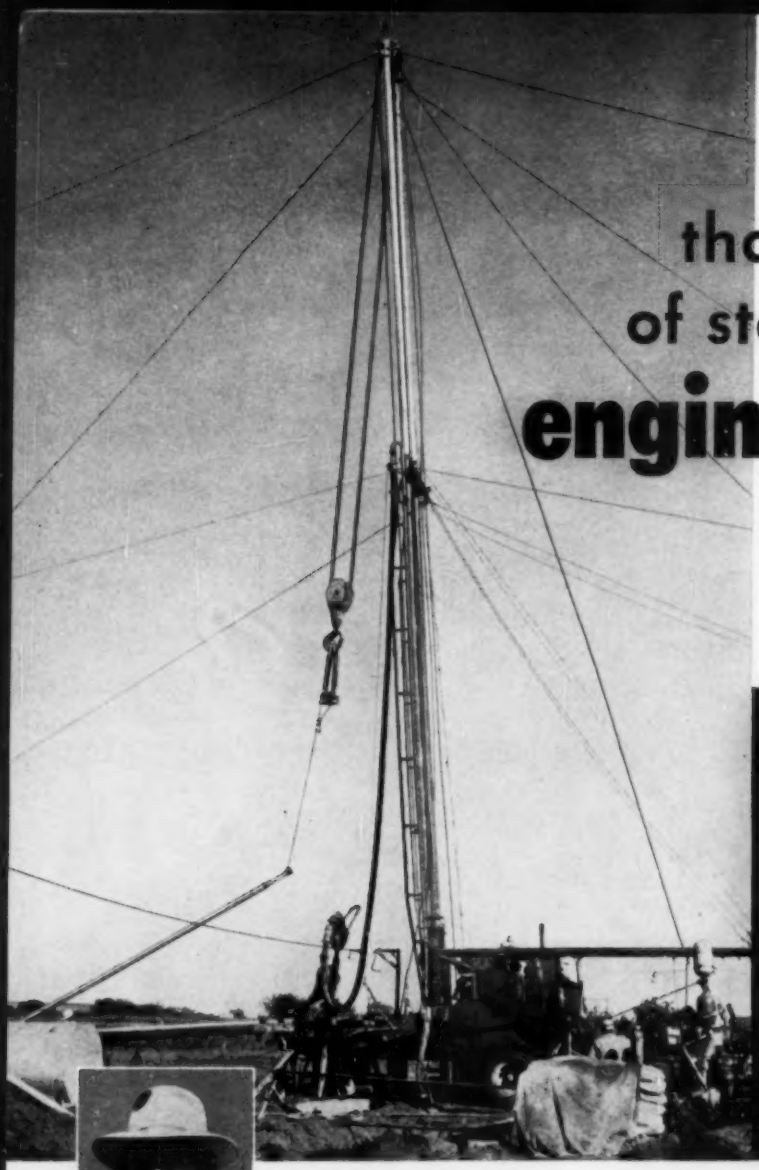

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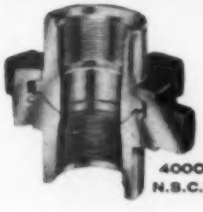

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KENNETH L. DIXON

MOST INDUSTRIES still consider public relations a luxury . . . a plaything . . . or even an aggravation.

They refuse to realize that it is a serious and all-important phase of their operation. They are blind to the fact that it can make the difference between profit and loss to their stockholders.

You think I'm wrong?

Well, how about the gas-gathering tax legislation right here in Louisiana?

Or how about that proposed federal law to cut into depletion allowance?

If the petroleum industry had maintained a good sound public relations policy over a period of years . . . if it has gained the understanding and the sympathy and the confidence of the people by telling its story — openly, honestly, and with pride — then it would have the public's sympathy today, and you wouldn't have to be worrying yourselves sick about what is going on in Washington or in any state capital!

Because, believe me, state and national lawmakers listen to the people. If they don't, they don't last very long . . .

But the unfortunate truth is that industry in general, and the petroleum industry in particular, does not have the faith, the confidence or the sympathy of the American people.

If you had it, you wouldn't have to worry about punitive and unfair legislation — on any level. At least, not over the long haul.

And you don't have it because you haven't paid enough attention to proper public relations policies . . .

Let's be specific:

The two chief flaws in the industrial public relations picture in this area in Louisiana as well as in other areas are these:

1. Industry's fairly consistent failure to put trained and experienced men in public relations jobs.
2. Even when it gets good public relations men, industry's insistence on tying their hands with outmoded policies, particularly the policy which says that all news, good or bad, involving local plants must emanate from or be approved by headquarters. (Usually this means New York, Baltimore, Pittsburgh, Chicago or some such place.)

Get Trained Men

Let's take a close look at that first flaw.

Too many industries still consider the public relations position as a sort of necessary evil. Headquarters says they have to have it, so they have it. But they turn it into a kind of semi-retirement post — or a convenient pigeon-hole for some vice president's relative who has been foisted off on the local plant and they don't know what to do with him.

That first example can be tragic to watch. They'll take some faithful, competent, longtime executive who needs to slow down but who doesn't want to retire as yet, and they'll farm him out to the public relations job. Usually he's a fine man with a pleasing personality, thoroughly likeable — and an expert in whatever specialized field he is being transferred from. But he knows nothing about news, the various news media, public relations principles — or even how to talk to the people who *do* know. Consequently, being completely ignorant of what he's supposed to do, he does the only thing he can — nothing.

Oh, he'll help a little bit by his personality — by drinking, playing golf and going fishing with the right people — but that's only a drop in the bucket when it comes to getting a public relations job done.

The personal tragedy in that situation is that he soon knows very well that he's been given what you might call a "half-pasture" job — and the pride he has taken in a lifetime's good work deteriorates into bitterness.

Meanwhile, the company's public relations grow unbelievably bad . . .

Do Not Gag Them

Now let's inspect the other major flaw in the picture — the case where good, competent public relations men are put in the proper job, and then handcuffed.

It is an absolute fact — and I can cite countless instances — that when any major news, *good* or *bad*, develops in an industrial plant, the only men who are competent to handle the job of getting that news out are promptly gagged. They have no more authority than a printer's devil — and as I was once taught, that's about as low as you can get in a newspaper plant!

Sometimes they are handcuffed at a local level, but more often the order — or the policy — comes from some far-distant headquarters. They are absolutely forbidden to give out any information whatsoever!

Now what in perdition is a public relations man for if not to give out information?

Let me tell you what happens when this sort of situation develops.

First, take an example of bad news.

In case of an industrial plant disaster, such as an explosion or a fire, it is a rare instance when any news medium — newspaper, radio station or TV station — can get any authorized, official information until it has been cleared either with the head man at the local plant or, more often, with headquarters in some eastern city.

Needless to say, the head man at the local plant is too busy doing whatever is necessary to cope with the disaster to waste any time monkeying with

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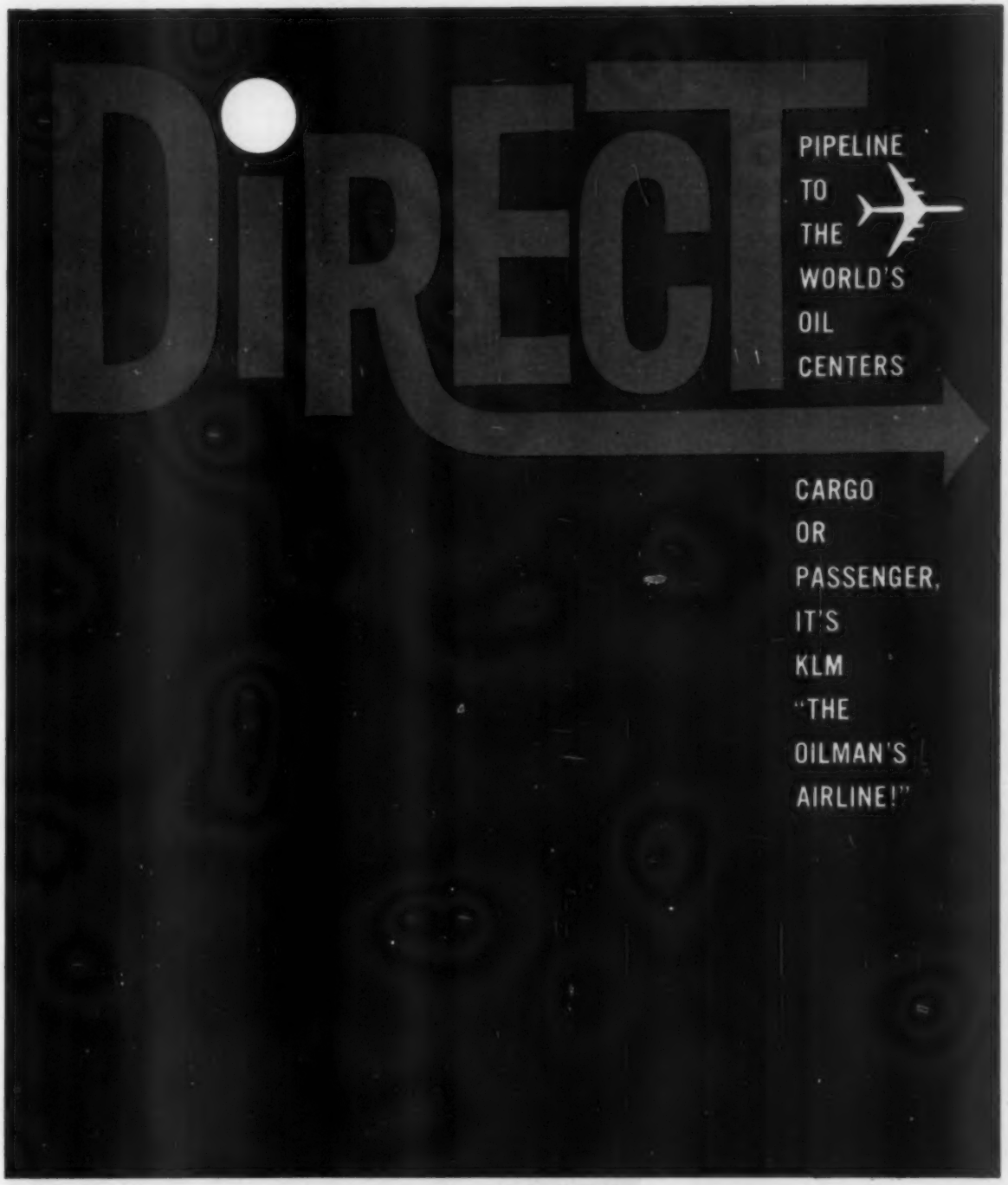
EDITOR'S NOTE: *This forthright advice was given by Mr. Dixon, editor of the Lake Charles (Louisiana) American Press to the Southwest Louisiana Chapter of American Petroleum Institute, Division of Production. It is seldom an editor of a local paper so frankly states his views of industry's short-comings in public relations. It is worthy of study.*



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news releases. And as far as the men in eastern headquarters are concerned, even if they can be found in a reasonable time — which rarely happens — they seem to have a stock answer: "Don't give out anything."

You see where that puts the community in general and us in particular. Lacking any authorized information from the industry, we then must resort to unofficial personal sources within the plant.

And this, far too often, results in misleading distorted or exaggerated accounts of what has happened, since those sources are neither professional newsmen nor capable public relations men.

Tell the Truth

Getting back on the subject, it should be obvious that these aforementioned unofficial and usually distorted accounts almost always do the industry far more harm than would a swift official report on the situation locally — no matter how bad it is.

Selfishly speaking, it certainly does us harm as a news medium, because we become guilty of publishing inaccurate accounts of what has happened — even though we carefully qualify the stories and stress that it's all unofficial and unconfirmed. But we can't just sit still in the face of an indicated major disaster, particularly when it seems to be leading to community hysteria.

And that brings up another point. I've mentioned how this sort of treatment of legitimate disaster news hurts the industry and hurts the news media. But the most important hurt of all is to the community itself — and chiefly to the families and friends of the people who work for industry.

When they hear, or hear of, or see a disaster, they understandably want to know immediately what happened. And when they can't find out, they grow frantic. They pile into their cars and jam the roads, streets and highways leading to the plants — creating terrific traffic hazards, causing more accidents, and impeding the work of all those who are attempting to deal with the disaster and its victims, if any.

How much better it would be if a trained public relations man were instructed, in all such cases to pick up the phone and call the radio and TV stations and newspapers and say something like this:

Tell It Quickly

"This is Joe Blow at the Worldwide Refinery. We've had some sort of explosion out here. No casualties have been reported. I'll call you back as soon as I have anything more on it. Ask people to stay off the roads."

Maybe later it would develop that there were casualties. If so, they could be reported as they were confirmed. Meanwhile, the company's quick action in telling the truth about the disaster would, over a period of time, give the families of its people a lot of confidence in it as a source of honest information — a confidence, which I am sorry to say, is pretty much lacking today.

More than that, such a prompt report would immediately isolate the disaster and take a great load off the shoulders of the other industrial plants in the area. And it most certainly would serve as a calming influence on the community as a whole . . .

Tell Good and Bad

But now let's pause and consider a minute. I'm perfectly willing to admit that this sort of conduct, this suppression or delaying of legitimate news, might be understandable, if not justifiable, if it were confined to the so-called "bad" stories — things like plant disasters.

Unfortunately it isn't.

We often get a number of news tips from thoroughly reliable sources about an upcoming plant expansion, for example, but we rarely can break the story loose at a local level.

Now bear in mind that this means more jobs, bigger payrolls and economic boosts to the community, but nine times out of ten we meet only with evasions, "no comments," flat denials or "this is off the record."

Here again, it's a matter of headquarters control.

We can, and usually do, smoke these stories out by long distance calls to the industry's headquarters — say, for example, New York — or have one of the wire services do it for us. But even that procedure usually results in the headquarters office breaking our story in the New York Times or the Wall Street Journal even before they turn it loose to us.

Now I hardly think that those papers would be offended—or would even be aware of it—if we broke the story on a local level either before they did, or at least simultaneously with them.

Here, too, it develops into a situation where, if we can't get the authorized and official facts, we are forced to print the unauthorized reports, and even though we label them as such, they certainly do not put industry's best foot forward in the area.

When it's bad news, the general public realizes that the industry is trying to minimize it as much as possible. That's understandable.

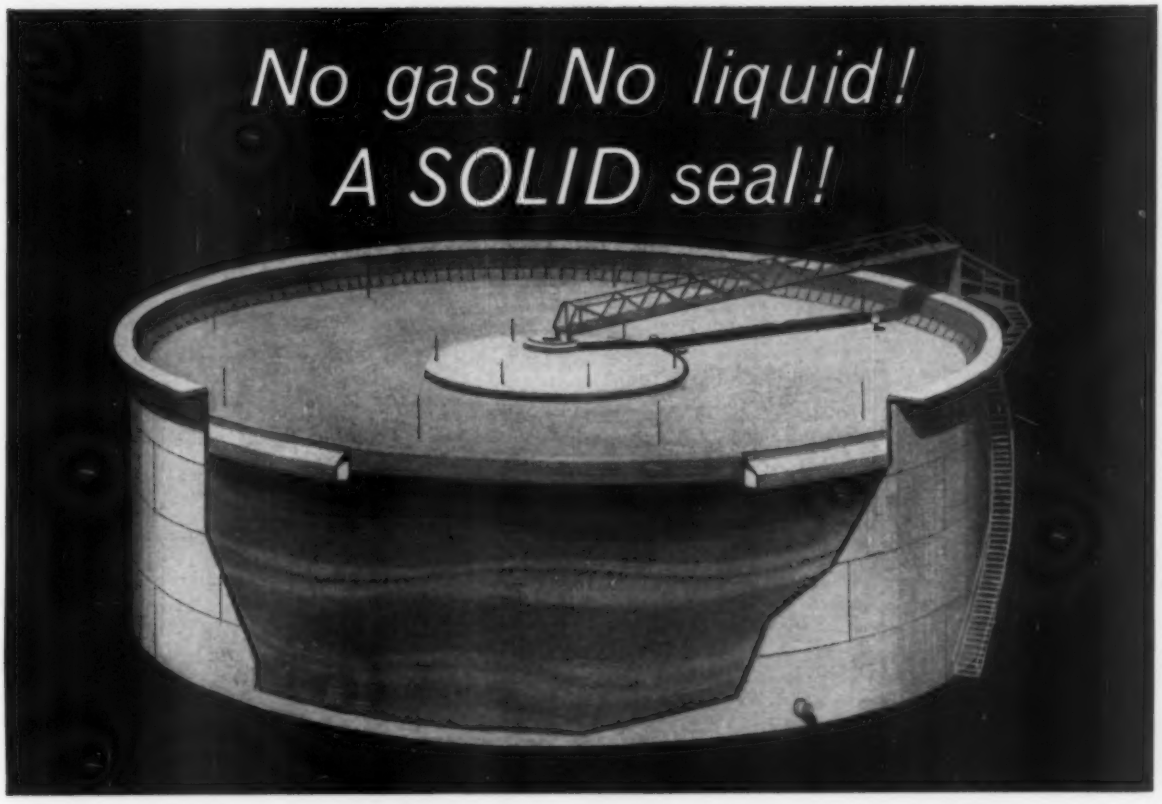
But when it's good news, and local plant officials still can't talk about it, the usual public reaction is: "What are they trying to hide?"

So much for good and bad news and the very realistic need to get it to the public as quickly and as accurately as possible. Let's go into what you might call a sort of in-between news—management-labor negotiations.

Tell Labor News

Very few things can be of more interest to a community than the status

SEE NOTHING, HEAR NOTHING, SAY NOTHING . . .



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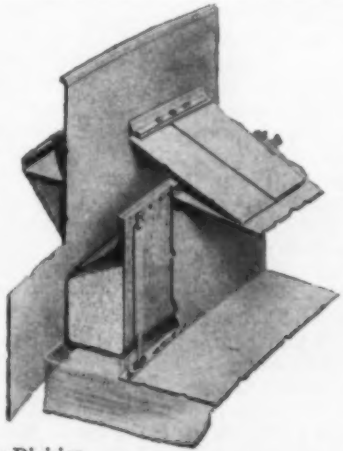

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of negotiations during a strike or even in the face of a potential strike. It can mean millions of dollars to the community's economy, but even more than that it can mean rent, grocery and utility money to thousands of families.

This, gentlemen, I submit is *completely legitimate news*—and under no circumstances should be suppressed!

Unless, of course, you have something to hide . . .

But what happens?

Not only does industry generally decline to give us any news at all about the status of such negotiations, but it also usually enters into an agreement with the labor representatives to refuse to release any news whatsoever about the situation.

Now, gentlemen, with half of the housewives of the community wondering and worrying about what's going on, with thousands of workmen trying to find out where they stand, with even many members of industrial management developing ulcers from frustrated curiousity, we're not going to sit still. *Particularly when we can get information.*

We can get it, directly or indirectly, from people who sit in on those very negotiations. They may not talk to us. They may keep their word. But they'll talk to somebody — their wives, their families, their fellow union leaders or their fellow executives in management. And somebody will talk to us.

So, once again, we are forced into the position of printing unofficial, unauthorized news about a major industrial story in our community. Once again, we label it as such—but people don't always notice the labels. And once again, we must print a story based on hearsay reporting by untrained reporters, and it may or may not be accurate.

But our duty is to our readers . . . to the community . . . and when a story which affects them is breaking, we can't sit still. Neither can the radio or television stations.

Management Suffers Most

The irony of all this is that industry suffers far more from such an agreement to surpass the news than does labor. In the first place, there are far more members of union labor available to bring their side of the story to us than there are members of management — but that's not the important point.

The important point is that strikes are seldom, if ever, popular — even with those who stage them. Even less often are they popular with the families of those who are striking.

Now, I am a firm believer in the right of a working man to join a union and to strike if he thinks he's not getting what he deserves. But I am not a believer in one or two union dictators — or management dictators, for that matter—being able to work hardships on hundreds or thousands of people by the simple expedient of not letting them know what is going on!

Industry's "gentlemen's agreement" —its public relations policy—in these matters makes that possible. You might give that a little thought.

Now I've been pretty rough. But I've paid you as high a compliment as I can—by assuming that you're too intelligent to want me to butter you up.

Actually I have a great deal of admiration for the oil industry — the petroleum industry and all its affiliates. Hells bells, I married into it! My late father-in-law was one of the last of the old school wildcatters—one of those who literally made and lost millions. But I'll guarantee you Mr. Sam would say today something like this: "Either be thickskinned, run your own business and don't bother about what other people think and the legislature does—or, if you're going to have a public relations man, get the best in the business and then let him handle it. If you have to tell him what to do, he ain't worth hiring!"

So if your industrial skin is getting a little thin and sensitive, if you feel that you need public support to do the job that must be done, then don't feel that you can skimp on public relations. Get the best you can get and then don't handcuff or gag them with a lot of ridiculous, outmoded, stupid policies.

Lest you think I'm alone in these sentiments, let me, in conclusion read you a couple of excerpts from a speech made in New York last month before the Manufacturing Chemists' Association winter conference. It was made by my friend Bob Akers, editor-in-chief of the Beaumont Enterprise and Journal. Bob said, in part:

". . . The public is reasonable. It will listen to an honest explanation. It will put up with a lot, if it believes you're dealing squarely. Its patience under those conditions may surprise you. But the public is also smart. You can't kid the people with 'No comment' remarks to the press, nor with trying to make conditions appear to be what they aren't . . .

". . . I mean this: An attitude of 'it's none of the public's business,' so far as your plant operations are concerned, an attitude of 'tell 'em nothing unless it has the official good news stamp of the home office' is the surest way to help produce a state legislature out to soak the corporations, to boost mineral taxes, to increase severance taxes.

"Heaven knows big business has about all the public regulation it can stand, but it will have to learn to stand even more unless it becomes a part of the community in every town in which it has plants, unless it communicates its story and honestly tells its sorrows as well as its joy to its neighbors of that community. Neighbors will sympathize as well as rejoice with you, if they have confidence in what you say.

"One thing I've learned is that the big, cold, impersonal corporation is really just the man next door who works for it. Invariably he's a man who believes in the company, is proud of it, is loyal to it. That gives everyone he meets greater confidence in the company he works for.

"Well, then, you the management of that corporation, be a 'next-door neighbor,' too. I get back to that same, simple rule: **Tell the Truth.**

"But, gentlemen, **tell** it!"

I cannot improve on Bob Akers' conclusion. ★ ★ ★

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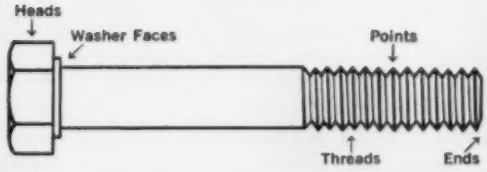

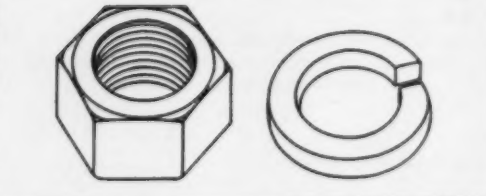

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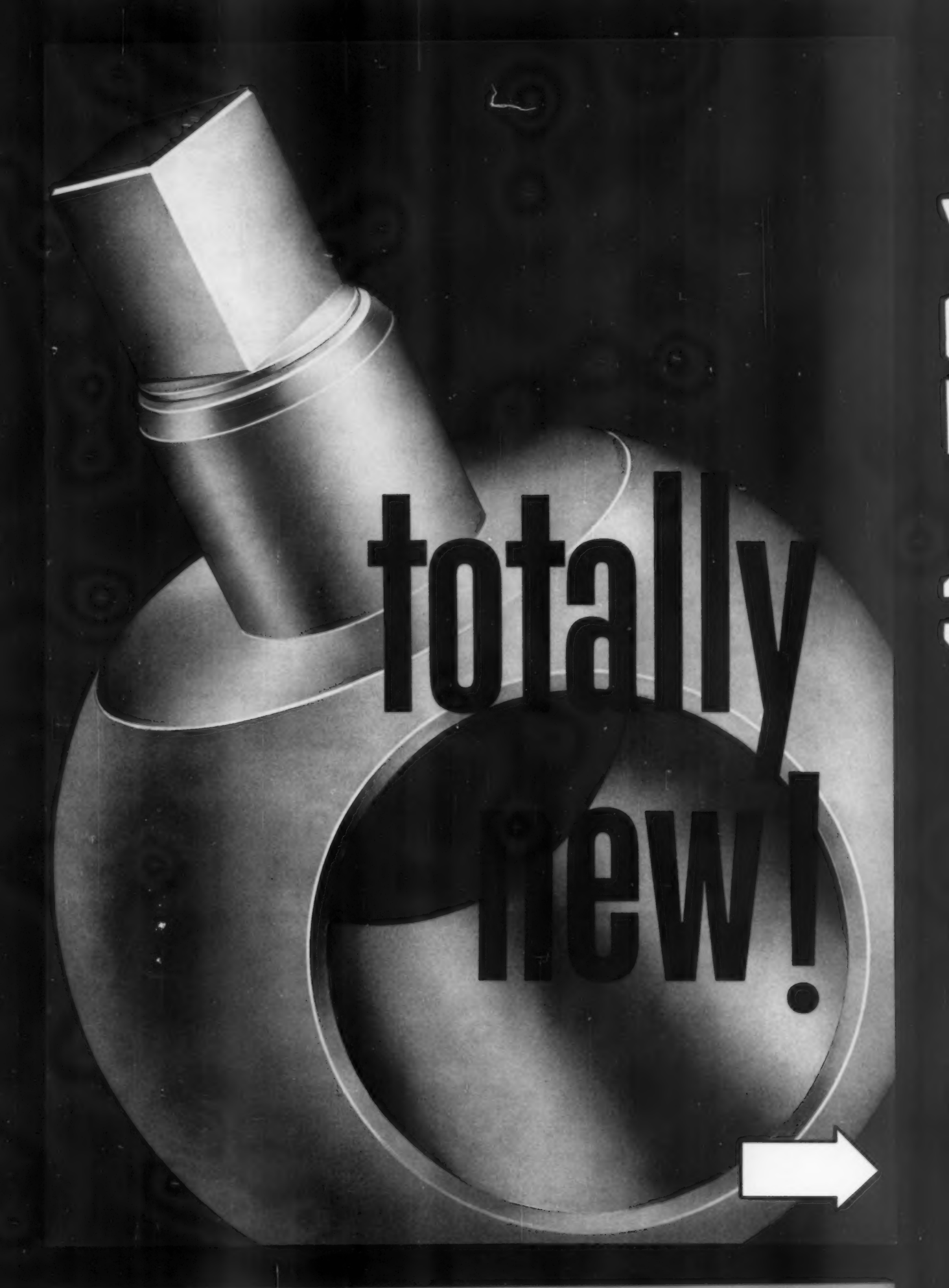
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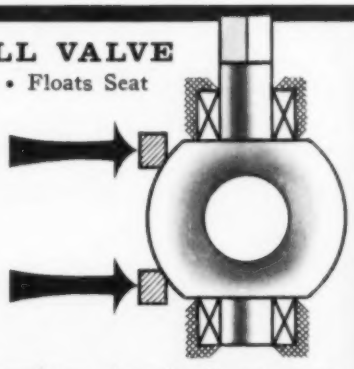

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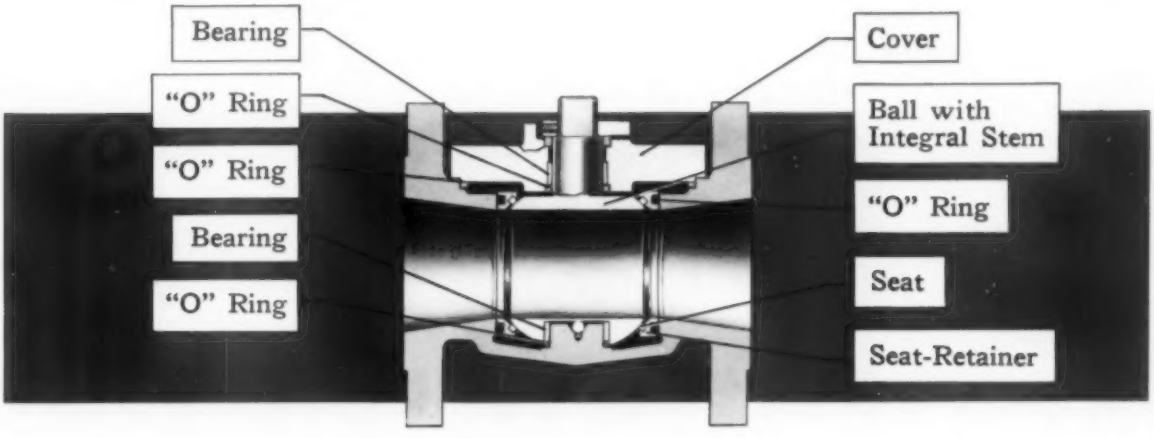

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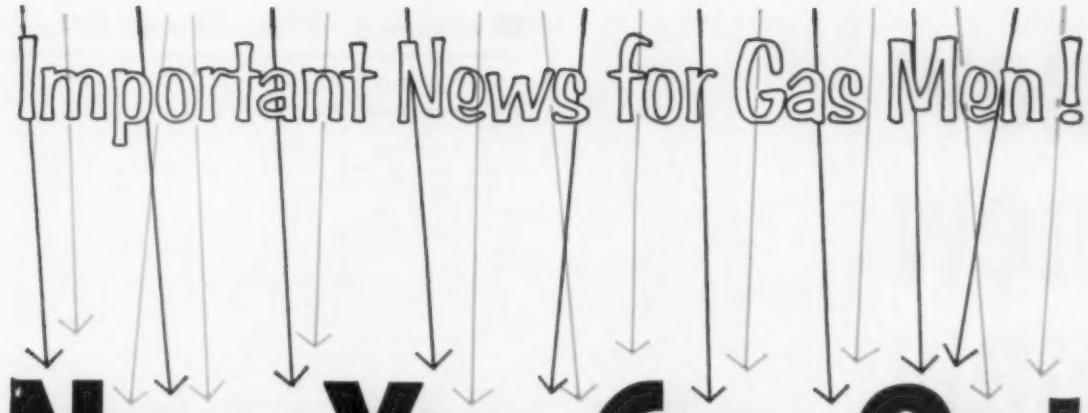

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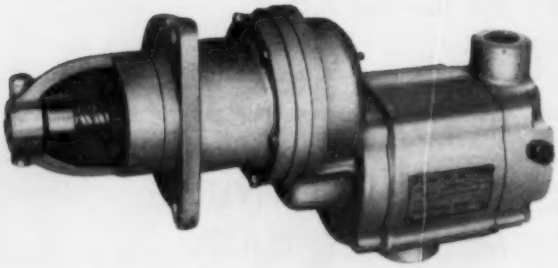

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Executive Public Speaking Techniques, *by Harry Simmons. Published by Chilton Company, Book Division, 56th and Chestnut Streets, Philadelphia 39, Pennsylvania. Pages, 231. Price, $5.*

The author says "Good public speaking is the measure of every modern executive," and he's written a book of proof here!

Simmons has taken an interesting approach. He has taken a survey of top executives on such questions as: "What do you consider the most valuable effect on executives of good public speaking?" and given the answers. Then the author launches into a why and how to speak—in your company and outside. This is worth your time if you're in management or intend to be.

Symposium on the Development of Petroleum Resources of Asia and the Far East. *A United Nations publication, distributed in the United States by Columbia University Press, 2960 Broadway, New York 27, New York. Pages, 251. Price, $2.50.*

This publication contains the report and the principal documents of the Symposium on the Development of Petroleum Resources of Asia and the Far East, which was held in New Delhi, India, from December 3 to 16, 1958, under the sponsorship of the United Nations Economic Commission for Asia and the Far East (ECAFE).

The book includes documents of general scope, documents pertaining to the ECAFE region as a whole, to petroleum resources development in countries of the region and outside the region, and to regulations governing petroleum development. Titles of some of the papers range from "Geologic Conditions Essential for the Occurrence of Exploitable Oil Accumulations" to "Experiments on Secondary Recovery of Crude Oil by 'Fire-Flooding' in Japan" to a list of drilling rigs available in Taiwan, China. This volume will be valuable to anyone interested in any way in the history and statistics of oil development in the ECAFE region.

International Economics of China, *edited by C. F. Remer. Published by The University of Michigan Press, Ann Arbor, Michigan. Pages, 221. Price, $6.*

For those who keep up with world economics, this study is comprehensive and revealing. It is difficult for Western nations to understand the policies and economics of a country where per capita income is less than $6 a year. Because of its population increase this income fell 4 percent between 1933 and 1956 when net production of goods and services increased by one third. It appears that until population control is effected, economic gains cannot make the leap for solid gains.

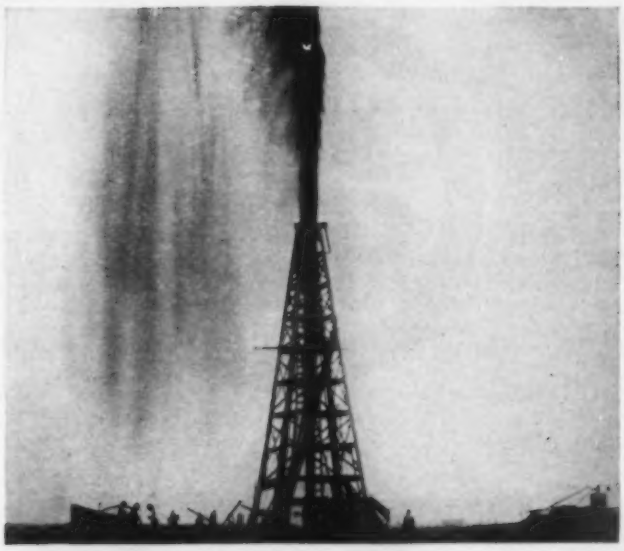
The First Five-Year Plan showed 1952 crude output 8720 bbl per day, with a target of 40,240 in 1957. That clearly was not made as reports give 18,000 bbl per day as production in 1958.

This volume is not easy reading for the layman, but it presents interesting possibilities. With less financial help from Russia and less return for labor, Communist China has an uphill fight.

Technical Writing Manual, *by Christian K. Arnold. Published by Electronic Periodicals, Inc., 2775 S. Moreland Blvd., Cleveland 20, Ohio. Price, $2.50.*

This is something a little different and certainly will be helpful to any writer — technical or not. One of our editors commented that the "technical" wasn't needed in the title. Such puzzlers as "farther/further," "possible/feasible" are dealt with simply and briefly. This manual is good as far as it goes but it doesn't go far enough. It needs to be more comprehensive.

The gusher that brought in 50,000,000 cars



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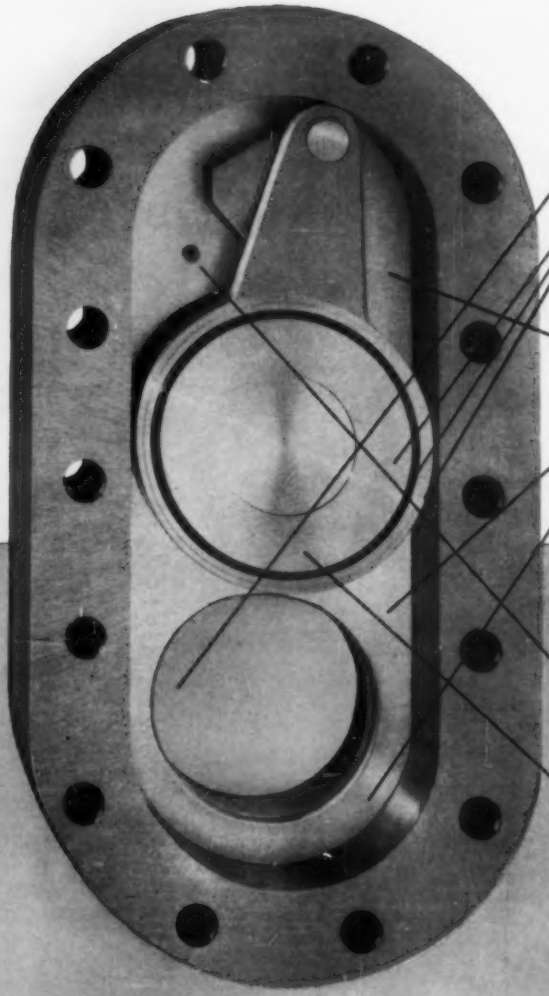

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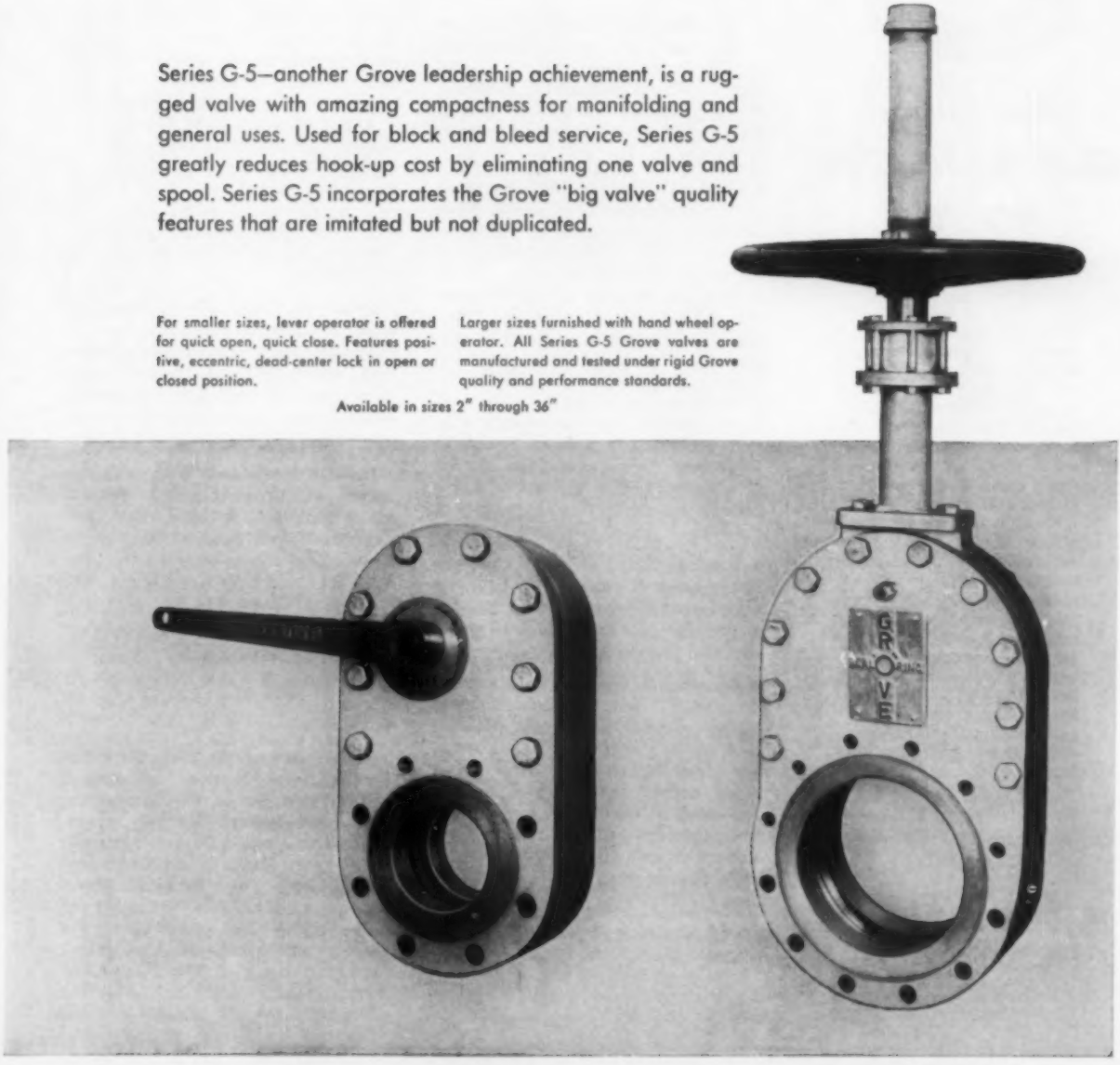

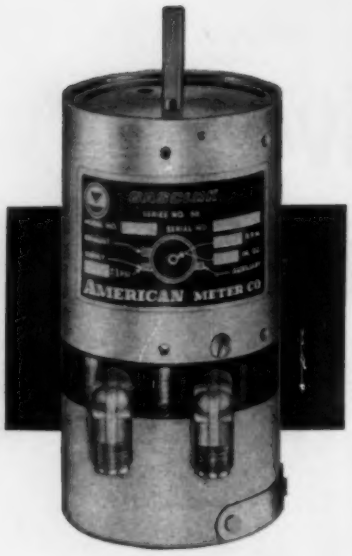

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Management Personals

▸ **K. H. Shaffer** was elected chairman of the board and **J. E. Gosline,** presently vice president and assistant to the president of The California Company, was elected to succeed Shaffer as

K. H. Shaffer

J. E. Gosline

president of Standard Oil Company of Texas.

The California Company has announced that it is contemplated that prior to the retirement of **H. C. Teasdel** June 1, 1960, he will become chairman of the board and will be succeeded as president of The California Company by Shaffer.

▸ **Charles D. Schnake,** former supervisor of publications for Sunray Mid-Continent Oil Company in Tulsa, was named public relations supervisor under **Luther T. Williams.** He will supervise all external public relations phases of the company's over-all program, including newspaper, trade journal, radio and television reporting, liaison with division office public relations programs, oil industry public relations projects and community relations programs. In addition, **Ronald L. Butterfield,** formerly staff writer, has been named public relations representative. Butterfield will report to Schnake.

▸ **Ralph L. Gray** was elected chairman of the board of Armco Steel Corporation. **Logan T. Johnston** succeeds Gray as president. Johnston has been executive vice president.

▸ **Barnabas B. Hadfield** was elected a director of Tidewater Oil Company to fill the vacancy left by the death of Gordon B. Crary. Hadfield is senior partner of the law firm of Hecht, Hadfield, Farbach and McAlpin.

Francis X. Owens was named training supervisor of Tidewater Oil's eastern division. He has been division sales training supervisor.

▸ **Howard G. Vesper,** president of Standard Oil Company of California, Western Operations, Inc., was elected president of Western Oil and Gas Association, trade association representing the oil industry in the six western states of Alaska, Arizona, California, Nevada, Oregon and Washington. Vesper succeeds **Olen Lane** of Continental Oil Company.

Other officers elected were **Howard C. Pyle,** president, Monterey Oil Company, first vice president; **George F. Getty II,** president, Tidewater Oil Company, second vice president, and **T. H. Wallace,** vice president, Western Gulf Oil Company, treasurer. **Felix Chappellet** was re-elected secretary, vice president and general manager of the Association. New members of the board of directors are Getty; **Ralph Edgington,** president, Edgington Oil Refineries, Inc. and **Harold C. Morton,** partner, Morton and Dolley.

▸ **John S. Sprowls,** vice president and assistant to the president, Vickers Petroleum Company, was elected to the board of directors. He was formerly assistant treasurer in charge of loans and related investments of Gulf Oil Corporation, Pittsburgh, Pennsylvania.

A. E. Collins and **L. W. Goudy** were elected vice presidents of Vickers Petroleum. Collins, formerly manager of production department, was named vice president of production and Goudy, formerly assistant exploration manager, was named vice president of exploration.

▸ **Robert D. Crane** was appointed director of purchases and traffic, Dresser Industries, Inc. The retirement of **Robert C. Kelley** was also revealed. Crane moves into the post from his former position as assistant director of purchases.

▸ **Howard Jensen,** well known Dallas attorney, and for the past 15 years a member of the firm of Burford, Ryburn, and Ford, has assumed the responsibilities of vice president-legal for Lone Star Steel Company. He has been handling labor matters for Lone Star for the past several years.

▸ **W. Frank Prendergast,** assistant to the president (public relations) of Imperial Oil Ltd., has retired after 32 years of service.

▸ **K. W. Brill,** New York City, was appointed vice president and assistant general manager of Continental Oil Company's Rocky Mountain region, with headquarters in Denver, Colorado. **J. P. Malott,** Denver, assistant general manager of Conoco's Rocky Mountain region since July 1958, was promoted to general manager of the company's western region, with headquarters at Los Angeles, Calif. **Olen Lane,** Los Angeles, vice president of Continental, will continue in that capacity and will devote the major portion of his time to industry affairs.

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▸ **N. M. Ekserdjian, N. Y. Ruth** and **L. R. Murphy** were appointed executive directors of the Iraq, Basrah and Mosul Petroleum companies. Ekserdjian is responsible for relations with governments, concessionary matters and personnel policy. Ruth has special responsibility for exploration and production. Murphy has responsibility for financial aspects of the companies' affairs.

▸ **Robert J. Bradley** was elected chairman of the board and chief executive officer of Producing Properties, Inc. He has been succeeded in the presidency by **Mac D. Oliver Jr.** A new post of executive vice president has been created under which all administrative activities will be performed. **Virgil B. Harris** has been elected to this position. **Lionel E. Gilly** remains as financial vice president and secretary. The executive committee includes Bradley as chairman, and **A. Knox Tyson** of Houston and **deBenneville K. Seeley** of New York who were formerly chairman and vice chairman of the board.

▸ **Arthur A. Curtice** has resigned as president and general manager of Signal Oil and Gas of Venezuela to resume work as a private petroleum consultant. With offices in Caracas, Venezuela, Curtice has headed the Signal Oil and Gas Company subsidiary since March 1957. Curtice's headquarters will be at Suite 516, 630 5th Avenue, New York 20, N. Y.

▸ **Henry W. Boggess,** manager of personnel for Sinclair Oil & Gas Company and director of aviation for all Sinclair companies, will devote full time to aviation duties as director.

▸ **Walther H. Feldmann** was elected a member of the board of directors of The Babcock & Wilcox Company. Feldmann is president and a director of Worthington Corporation.

▸ **Wm. J. Zeman** was promoted to general attorney, succeeding **Harry D. Turner** who becomes special counsel with offices in Tulsa, Okla.; **H. K. Hudson** has been named counsel on special assignment, and **Lloyd G. Minter** becomes general attorney, Phillips Petroleum Company. Zeman has been an assistant general attorney, Turner, general attorney, and Hudson associate general attorney.

In its research division, **F. E. Frey** and **A. Clark** were named senior scientists. **D. E. Carr** advanced from assistant director to deputy director of research, and **W. W. Crouch, J. E. Mahan** and **D. C. Smith** were promoted to assistant directors. Carr will have prime responsibility for fuels and lubricants research, Crouch for synthetic rubber and polyolefins, Mahan for chemicals, and Smith for physics and production research.

R. D. Bent

R. E. Williams

▸ **Robert D. Bent** was elected a director and vice president and will continue as general manager of the manufacturing department of The Atlantic Refining Company. Bent fills the unexpired term **W. F. Stroud,** who retired from active management last June and now has resigned as a director.

Ross E. Williams was appointed manager of the domestic crude oil valuation and budget division, succeeding **W. F. Maxwell,** who retires after 42 years. Ross was assistant to the vice president and general manager of domestic and foreign crude oil production.

▸ **Alexander F. Imlay** was elected secretary and treasurer of Esso Standard Oil Company. He succeeds **Lester R. Moore,** now treasurer of Humble Oil & Refining Company (Delaware), the new principal domestic operating affiliate of Standard Oil Company (N. J.), Esso's parent firm.

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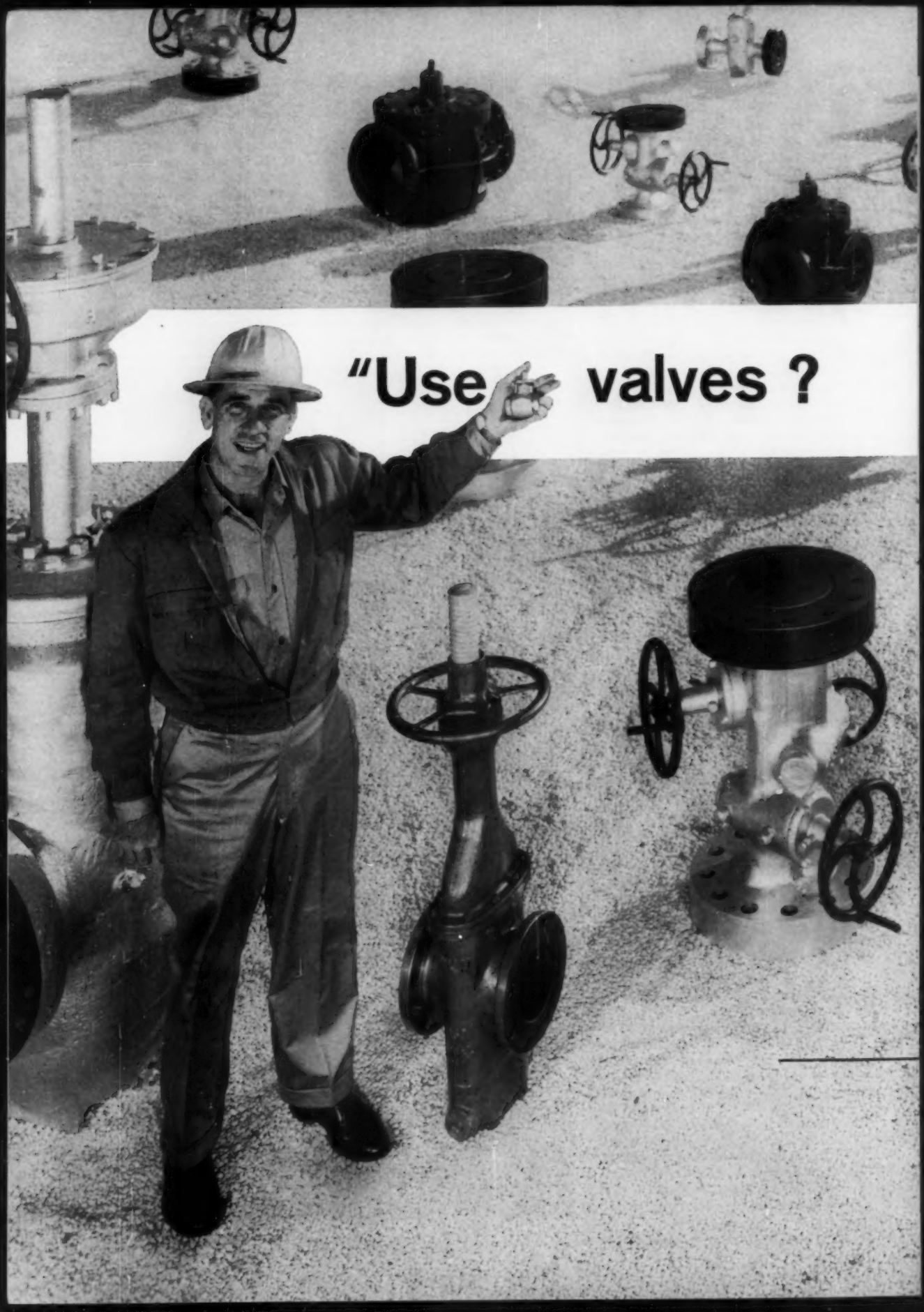
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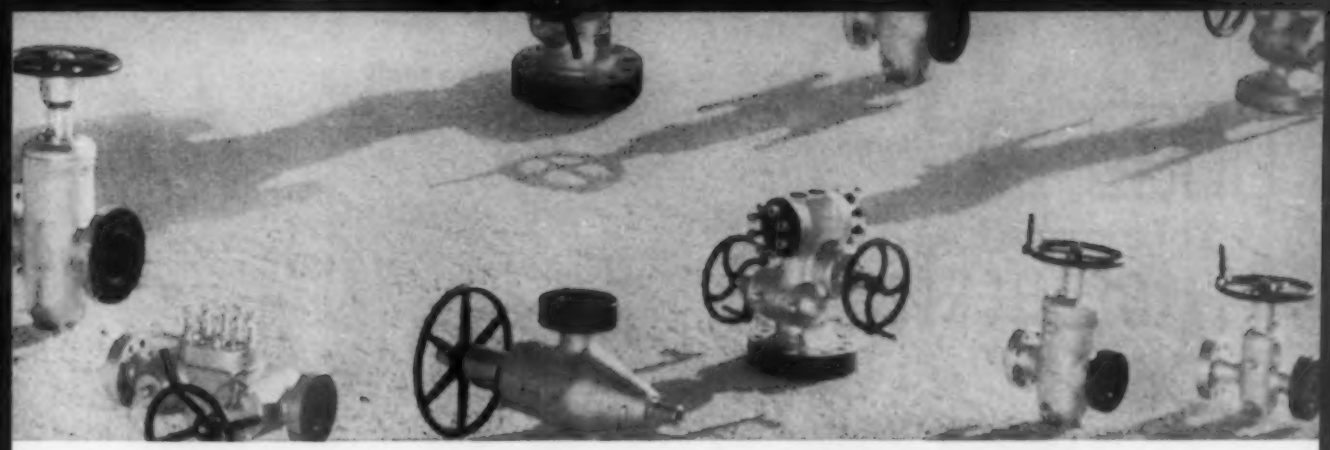

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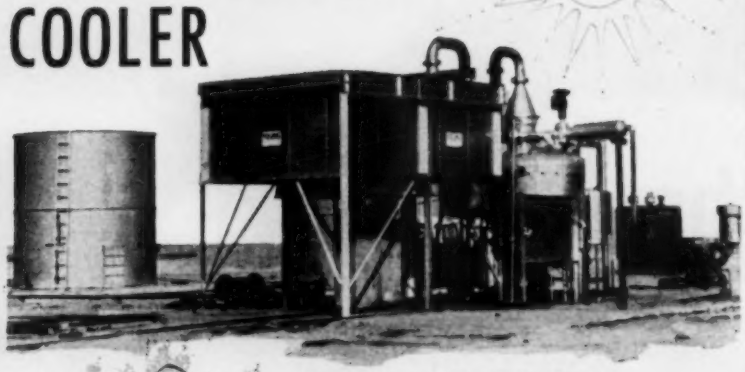

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Personals

John R. Penn Jr., Fort Worth investor, was named to the board of directors of Texas Pacific Coal and Oil Company.

J. R. Penn Jr.

M. F. Wirges

M. F. Wirges was appointed chief engineer of Arkansas Fuel Oil Corporation. Wirges was formerly manager of the company's natural gasoline division and succeeds **L. F. Babcock** who retired. Wirges will in addition be responsible for the company's economic and planning activities.

William I. Patrick was elected president succeeding **B. G. Tchalidy** who is retiring after 37 years of service in Argentina for Esso S.A.P.A. Patrick has been vice president.

E. D. Brockett was elected executive vice president of Gulf Oil Corporation. He has served as president of British American Oil Company, Inc. since 1958, and prior to that as coordinator of production on a world-wide basis for Gulf. He has been a Gulf vice president since 1955.

DEATHS

Charles C. Kenney, 51, assistant to the executive vice president of the Ohio Oil Company, died unexpectedly of coronary thrombosis December 6.

Quinton S. Peters, 40, assistant manager of public relations for Sunray Mid-Continent Oil Co., died in a Tulsa hospital December 9 after failing to recover from an operation for cancer of the stomach performed in August.

W. O. (Sonny) Calvert, 53, former overseas representative for several Houston based oilfield goods manufacturers, died November 28 in Houston.

Dr. John V. Starr, 57, manager of the products planning division of Esso Standard's Petroleum Specialties Department, died December 6, at his home in Cranford, N. J.

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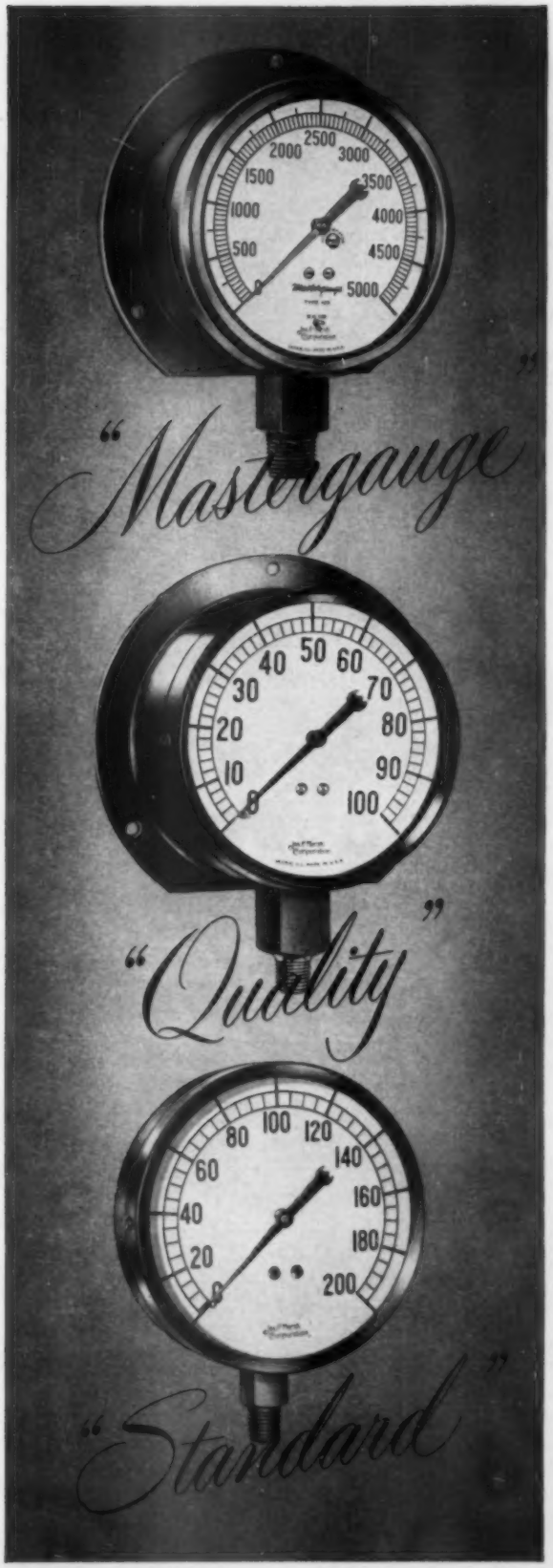

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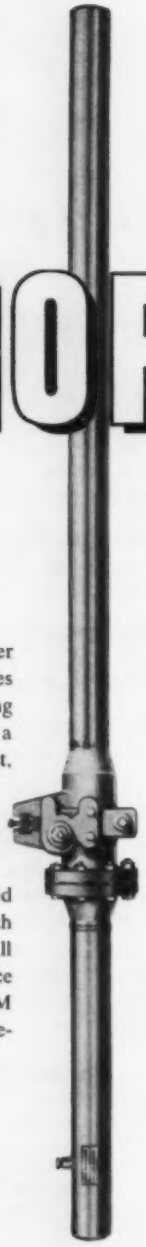

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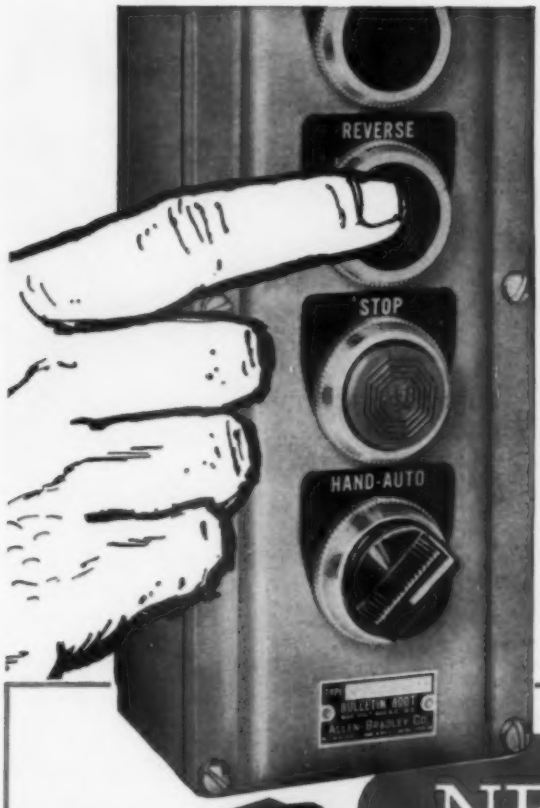

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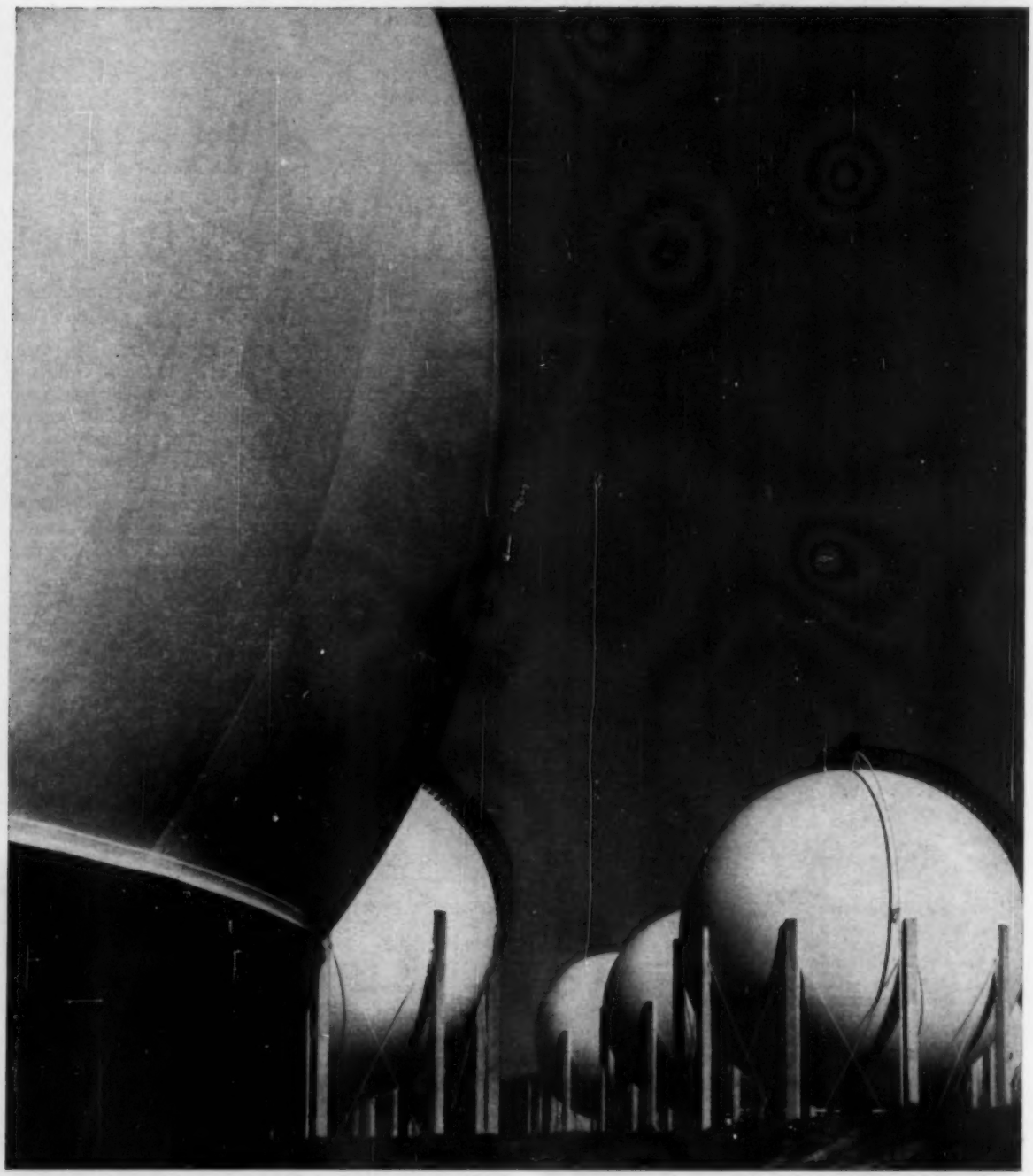

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WHEELING MACHINE PRODUCTS COMPANY

WHEELING, WEST VIRGINIA
WEST COAST FACTORY: WOODLAKE, CALIFORNIA

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BALL BEARING MOTORS

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They are specifically designed to overcome the unusual conditions of Oil Field requirements, and there is a type and H.P. built to fit your exact needs. Unexcelled since they are . . .

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SEMI-ENCLOSED — normal or medium slip, 3 phase, 60 cycle. Has prelubricated ball bearings in semi-enclosed protected housing, 40 degree C rise. Built for continuous duty. **High Torque, low starting** current. Extra insulating coating throughout.

TOTALLY ENCLOSED — Fan cooled, normal or medium slip, 3 phase, 60 cycle. Has prelubricated ball bearings, totally enclosed FAN cooled 55 degrees C rise, for continuous duty. High Torque — low starting current. Extra insulating coating throughout.

Write for fully descriptive literature

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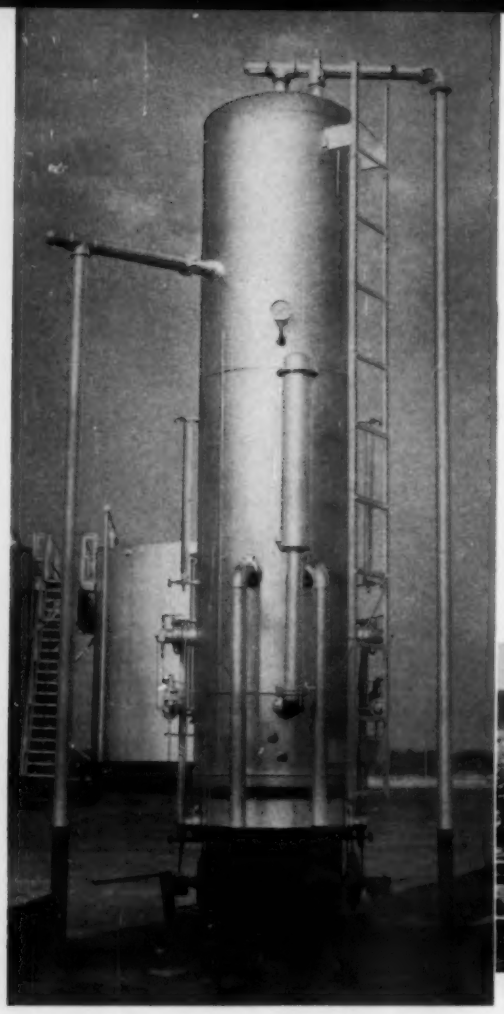
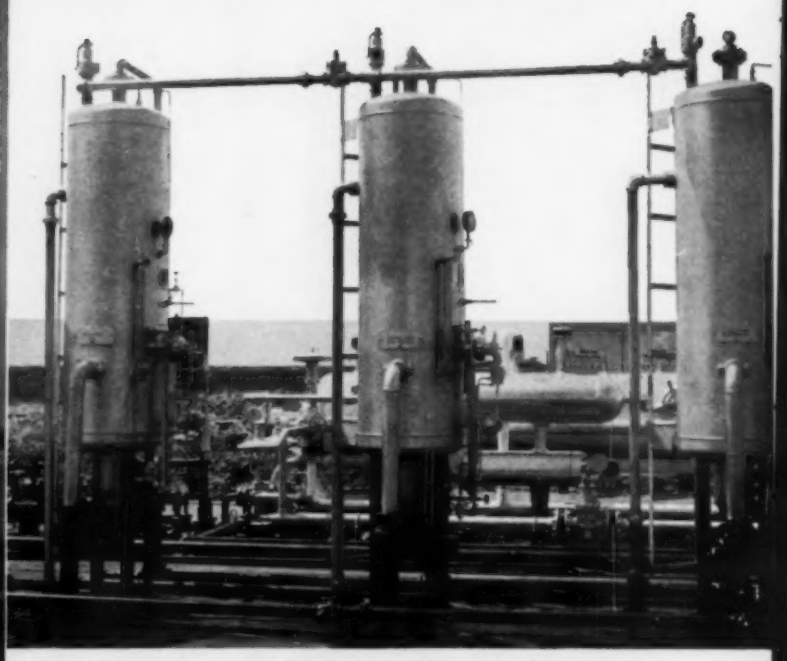


National Three - Phase (Oil - Gas - Water) Metering Separator in West Texas separating and measuring oil and water for individual well testing.



National Two-Phase (Oil-Gas) Metering Separators being used as LTX flash separators to measure distillate production from individual wells for commingling.

In The Separator Section

1. The long proven National Standard Gas Scrubbing Element assures liquid free gas.
2. A spreader plate insures degassing of the oil and provides the quieting section essential for efficient separation.
3. Ample storage of oil in a turbulent-free section provides stabilization and prevents carry-over during meter discharge period.

In The Liquid Metering Section

1. Reduced liquid surface area at both high and low level assures minimum metering error.
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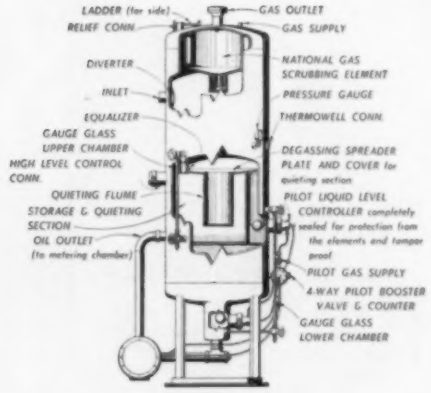
3. Prefabricated piping furnished for ease and speed of installation.



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"Yes, sir, that's right—too many logs!

"You see, today we have over 40 different types of logging services to choose from, so it's no wonder our wells are sometimes "over logged," inadequately logged or logged with the wrong tool. But now we have a new easy-to-use logging program developed by Welex."

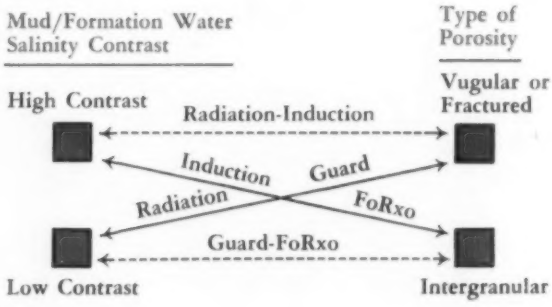
Here's a smart well man who knows that regardless of how many logs he runs, he needs the answers to two main questions. What is the POROSITY? What is the FLUID SATURATION?

Welex's new easy-to-use logging program is based on four Welex logging services — the Guard-FoRxo, Induction-FoRxo, Radiation-Guard and Radiation-Induction. One of these four services will give fast accurate answers in more than 90 percent of today's wells.

The diagram shown here indicates the right service, based on the type of mud and type of porosity.

And with Welex's easy-to-use interpretation charts, or "pigtails," printed right on the log, anyone can read the "answers" directly off the log with the speed, accuracy and confidence of an expert.

Welex's new easy-to-use logging program reduces confusion, costs and complicated computations. Call your nearest Welex representative and get the best.



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Of Things To Come . . . In Oil

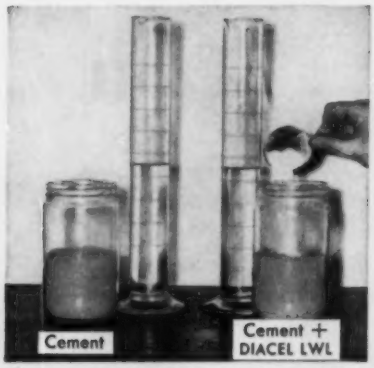
PREDICTIONS OF IMPROVED DRILLING were made by two executives of Dresser Industries, Inc. in a letter to share-holders. "The outlook for drilling in 1960 is difficult to project with any certainty, but a careful appraisal of those factors which influence the level of drilling suggests rather strongly that a further improvement will occur," said H. B. Mallon, president, and J. B. O'Connor, chairman. "New product developments in many areas already have resulted in a volume of new orders that assures a high level of activity within this substantial segment of the company's overall operations," they added.

COURT HASSLE OVER FRACTURING AND ACIDIZING will result from the controversial small-tract wells drilled in southwest Texas. Two operators have already sued to prevent such stimulation on the grounds that the resulting fissures would trespass on surrounding tracts. The suits are aimed to discourage drilling under Texas Railroad Commission Rule 37, permitting well spacing exceptions on town lots. Controversy has arisen from claims that fractures can extend as much as 550 ft from the wellbore — a distance that exceeds the 330-ft minimum that must separate Texas wells drilled on standard 20-acre units.

LOUISIANA PRODUCTION WILL HIT MILLION BBL PER DAY in 1960, according to Charlie S. Wilkins, executive vice president of the Louisiana-Arkansas division of the Mid-Continent Oil & Gas Association. If forecasted market demands hold true, the state's output will increase from the 1959 average of about 980,000 bbl per day to well over 1,000,000 bbl per day. The 1959 figure represents an increase of 14 percent over 1958 production figures and establishes Louisiana as the second largest oil producing state, taking the honor from California.

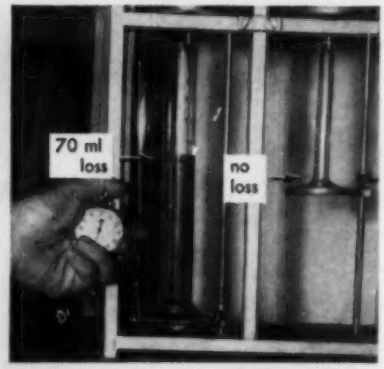
$200,000,000 WILL BE SPENT IN CANADIAN EXPLORATION during the next 10 years, according to officials of the Department of Northern Affairs and National Resources. Additional exploration permits will be issued for the northern mainland where acreage already under permit totals more than 92,000,000 acres. In the Arctic Islands, farther north, applications for oil exploration permits had reached 105,000,000 acres at the end of 1959, signaling a large increase in exploratory drilling which is anticipated to start within the next two years.

SEE the difference that MAKES a difference...

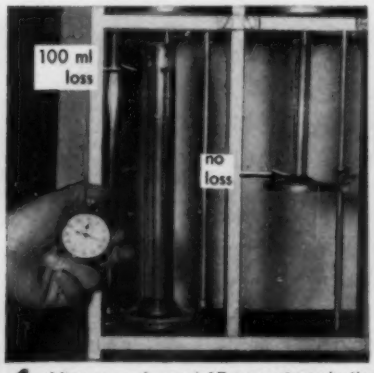


1 Demonstration begins with 2 jars of Portland cement (500 gms each) and 2 graduates of water (275 mls each). 2.5 gms of DIACEL LWL are added to cement at right.

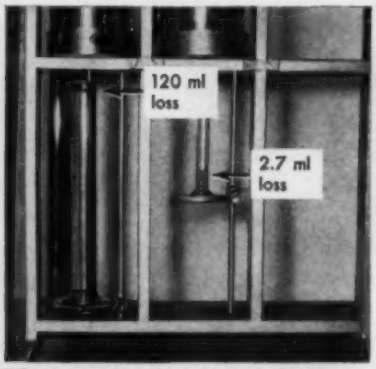
2 After mixing in separate blenders, cement slurries are placed in filter presses. Air pressure of 100 p.s.i. is applied to each. Slurry with DIACEL LWL (½% by weight) is at right.



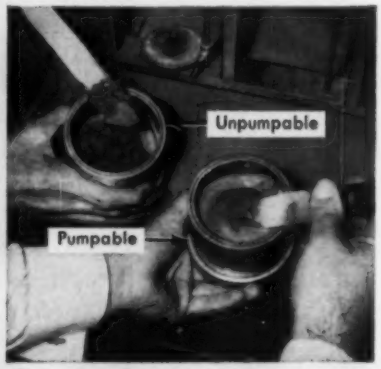
3 Water pressed from slurries drips into graduates and is measured. After just 35 seconds, slurry in press on left without DIACEL LWL has lost nearly 70 mls of water.



4 After one min. and 17 sec., slurry in the press on right with DIACEL LWL has not yet lost any water. Untreated cement has now lost over 100 mls of water.



5 After 10 min. under 100 p.s.i., cement with DIACEL LWL has lost only 2.7 mls of water (in small graduate). The other cement slurry has lost over 120 mls.



6 Opening filtration chambers shows cement with DIACEL LWL on right still fluid and pumpable. Cement without DIACEL LWL has dehydrated and is unpumpable.

The Best Low Water Loss Cement Slurries Are Made With DIACEL* LWL

The laboratory demonstration above shows how adding a very small amount of DIACEL LWL to cement will provide low water-loss slurries that help prevent sticking, flash setting, and water damage to potential pay zones. The ability of DIACEL LWL to control water loss and thickening time makes it especially beneficial for squeeze jobs and for cementing deep, hot wells.

With versatile DIACEL additives, you can tailor-blend cement slurries that meet practically all conditions. This tailor-blending saves you money in much the same manner as engineering your casing string. It will pay you to get complete details and technical literature on all DIACEL CEMENT SYSTEMS. See your Drilling Specialties field engineer... or cement service company.

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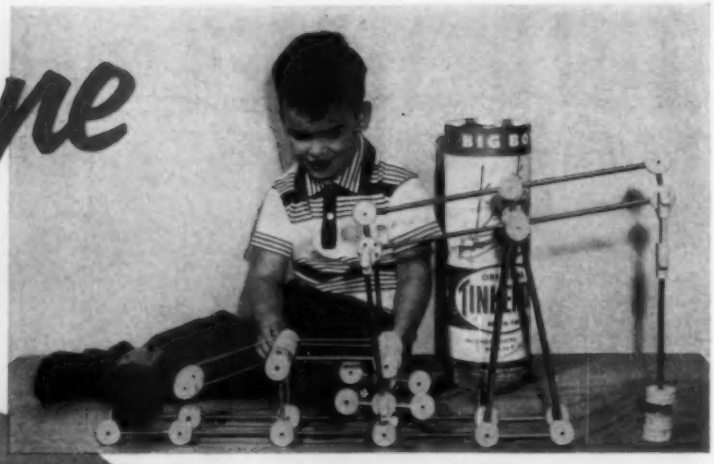

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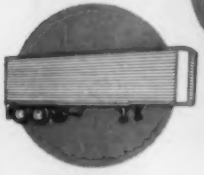

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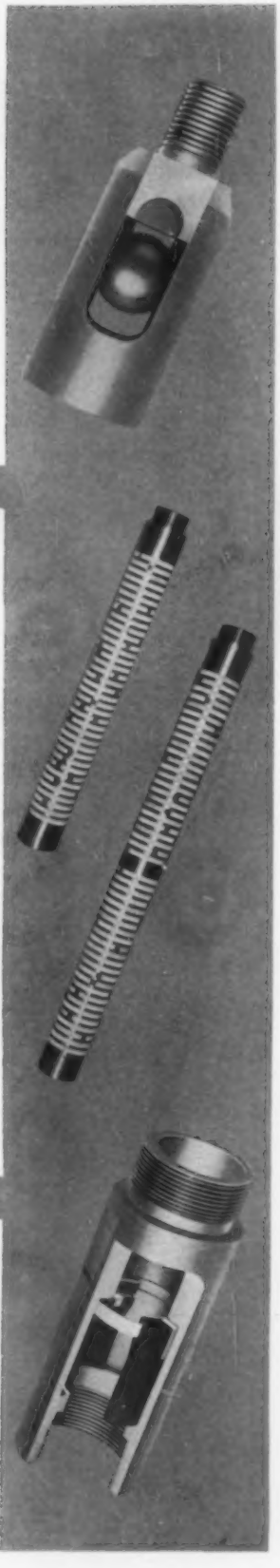

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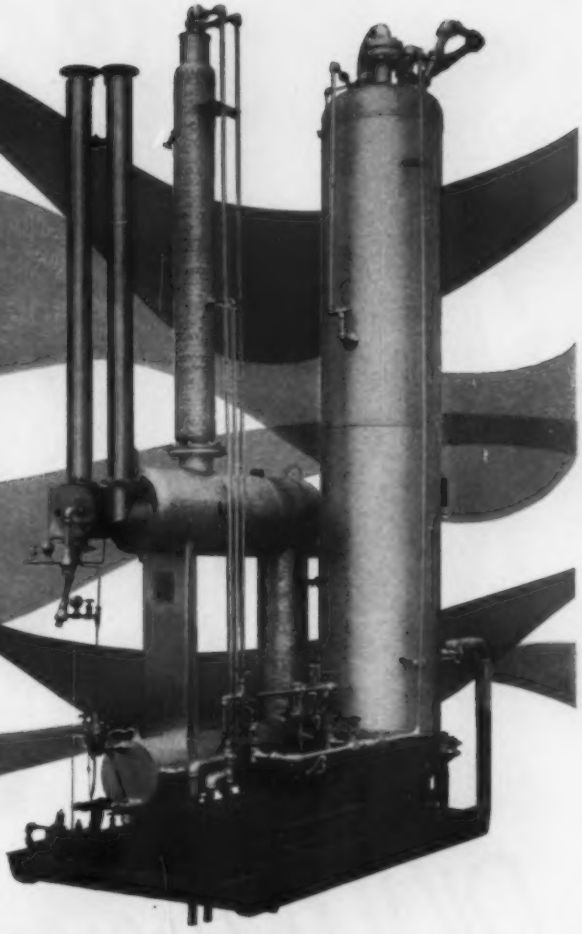

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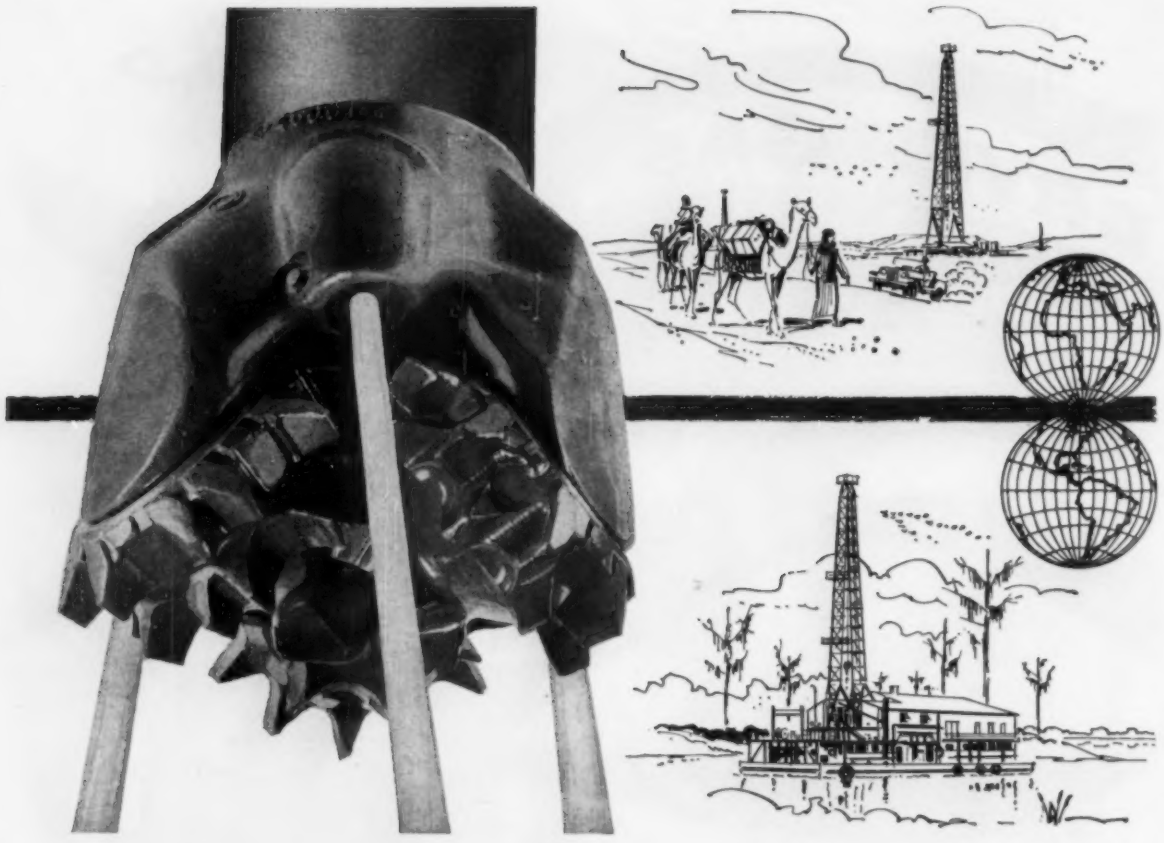

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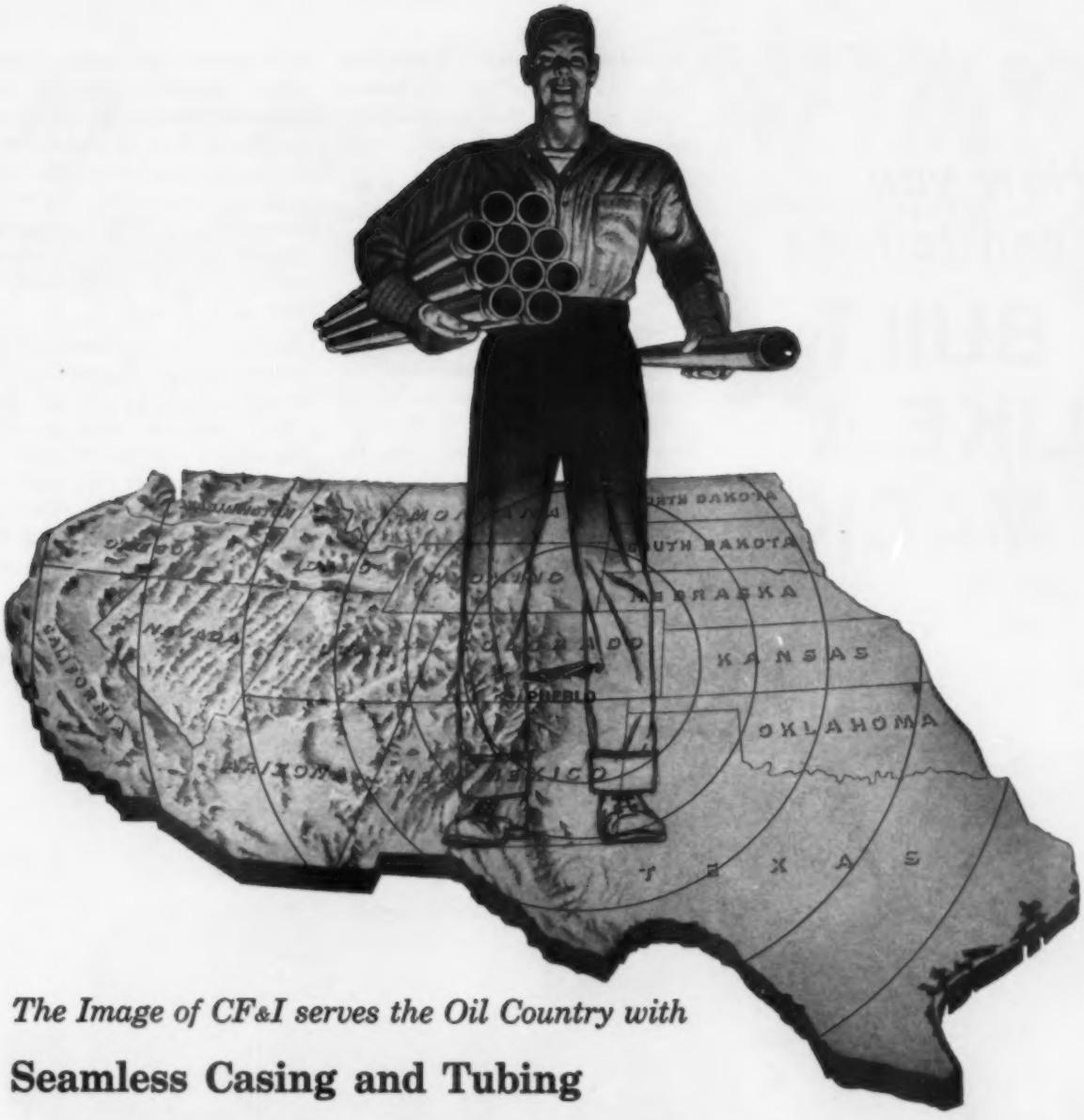

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Note the business-like looks. No costly, useless passenger-car styling frills. And even older Mack trucks are a cinch to recognize—partly because of the sturdy construction that's a Mack trademark . . . partly because Mack users take extra pains to maintain their top earners in like-new condition.

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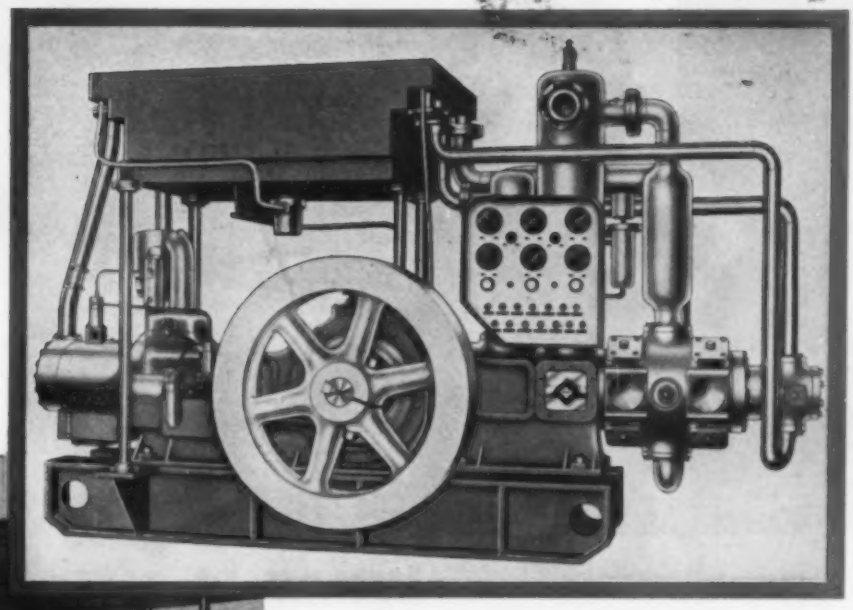
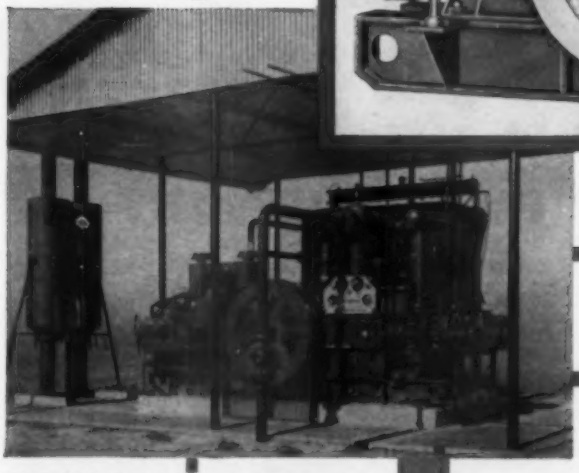


Shown above — the new DPC-60
Single Cylinder Engine-Compressor



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Ajax equipment — engines - pumps - compressors — have proven themselves through the years.

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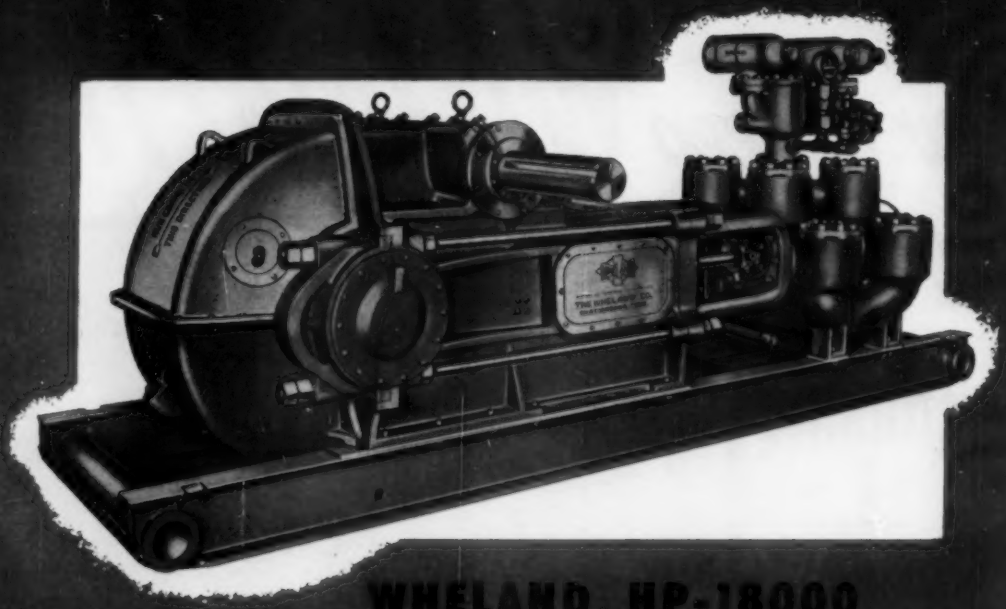

WHELAND HP-18000
DUPLEX POWER SLUSH PUMP
7¾"x18" 750 HP NOMINAL INPUT at 60 RPM

WHAT IS THE *OPTIMUM* PUMP FOR YOUR JOB?

You consider the pressure and volume needed, the weight and cost of moving the pump, the cost of power to drive it and your initial investment.

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Detailed bulletin sent on request.

It will pay you to see if this isn't the *OPTIMUM* pump for your job, too!

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THE WHELAND COMPANY
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DRAW WORKS • SLUSH PUMPS • ROTARIES
CROWN BLOCKS • TRAVELING BLOCKS • SWIVELS

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A superior thru-tubing jet perforator featuring:

ENCLOSED FIRING SYSTEM

MINIMUM DEBRIS

DEEP, CARROT-FREE PENETRATION

HIGH WELL FLOW INDEX

ALL NEW McCULLOUGH *mac-jet*

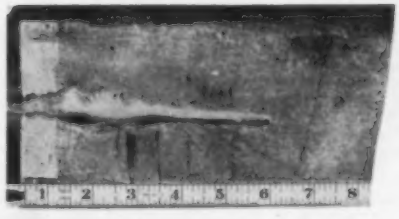
The McCullough Mac-Jet is an all-new development in expendable jet perforating – designed to provide maximum perforating efficiency – to obtain highest production from thru-tubing and slim hole completions.

- Enclosed Firing System – Each Mac-Jet unit is self-contained, including jet charge and integrated firing system, enclosed in a frangible, high strength case. This design eliminates the use of exposed primacord. Units are securely locked together and may be fired from bottom up or from top down.
- Minimum Debris – Entire Mac-Jet Perforator breaks up into small bits when fired. Mac-Jet units, spacers and bottom firing assembly are all disintegrating to assure complete break-up.
- Superior Perforation Characteristics – "big gun" performance – penetration equal to or better than that of many larger jet casing guns. Carrot-free perforations, large deep holes, high well flow index.
- Size, Shot Density, Length – 1 11/16" OD and 2 1/16" OD. Standard shot density is four per foot, 90° phasing.

Disintegrating spacers are supplied to provide fewer shots per foot when required. Any number of Mac-Jet units may be run in any length desired.

SPECIFICATIONS:

	1 11/16" OD	2 1/16" OD
Pressure, Temperature Rating	15,000 psi. @ 300°	13,500 psi. @ 300°
Maximum Temperature	350°	350°
Total Charge Weight	12 grams	20 grams
Av. Penetration (Berea Sandstone)	5.69"	7.45"
Av. Entrance Hole	13/32"	7/16"
Av. Well Flow Index	1.1+	1.44
Fill-up – 1' Gun, 5 1/2" Casing	1"	–
Fill-up – 1' Gun, 7" Casing	1/2"	1"



Standard Berea Sandstone target perforated by 1 11/16" OD Mac-Jet. Average penetration, 5.69"; average entrance hole size, 13/32; average well flow index, 1.1+.

DISINTEGRATING SPACER – Available in various lengths to provide fewer than four shots per foot. Disintegrates into small bits when perforator is fired.

McCullough *TOOL COMPANY*

LOS ANGELES • HOUSTON • EDMONTON • *CABLE ADDRESS: MACTOOL*

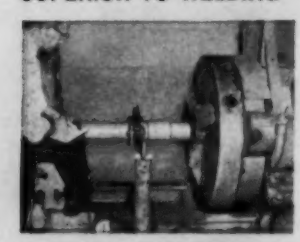
Avoid the harmful effects of welding on high-grade casing shoes and collars by using BAKERLOK.

Bakerlok—instead of Welding!

***BAKERLOK'D** joints withstand greater break-out torque than welded joints —at one-fifth the cost!*

***Thousands of** field applications, months of laboratory testing, provide positive proof of performance.*

BAKERLOK PROVED SUPERIOR TO WELDING

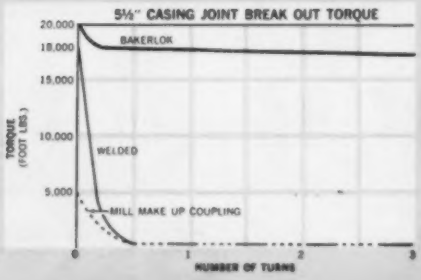


The break-out tester (above) was used repeatedly for simultaneous breaking-out of identically made-up joints, one with BAKERLOK on the pin *threads only*, and the other joint welded with three two-inch beads. Gradually increasing torque was applied, and . . . time after time the welded joints broke first. Further tests under constant vibration, with variances in make-up and temperature proved beyond question that BAKERLOK was far superior to welding.

See from the chart how BAKERLOK maintained a residual resistance, after breaking-out, greater than the welded joint.

In other tests to establish lubricating and sealing qualities, BAKERLOK joints made-up easier and tighter than when an A.P.I. Modified Thread Dope was used—and there was *no leakage* under extreme hydraulic pressures.

From Canada to Venezuela, BAKERLOK has been well-tested in thousands of applications. Ask your supply store for genuine BAKERLOK for your next casing job.



BAKERLOK THREAD LOCKING COMPOUND

Write for descriptive BAKERLOK folder.

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be largely determined by how good

As a general rule, a complete three-

single-phase motors on regular order.

Early planning and periodic re-evaluation are essential for . . .

Lowest Purchased Electric Power Cost

The cost of purchased electric power is usually just about what the operator makes it. By careful planning and control, such costs will be favorably competitive with other energy sources

John M. Stevenson, *Consulting Engineer, Dallas, Texas*

THE OIL INDUSTRY TODAY has two routes to better profits — either sell more oil or produce the same amount of oil at less cost. Since over-production is our pressing problem today, cost reduction promises greater dividends. Many improvements have been made in reducing production costs. However, there is still much room for improvement in one phase of operating cost reduction.

The cost of energy to produce and move oil in most cases is second only to investment and labor costs, yet this cost is seldom given the consideration it deserves, both in initial project planning and in everyday operations. When we speak of energy we include all forms of energy, whether purchased electric power, engines, or other types of power.

The Cost of Energy

The importance of energy costs suggests that they be among the first items considered in planning a field installation. Unfortunately, however, they are many times overlooked or disregarded until the last moment. It is not at all uncommon for an installation to be almost complete before provision is made for all of the energy requirements. This usually makes the overall cost of such energy much higher than it need be.

If energy costs are to be held to the absolute minimum, as pointed out in a previous paper,[1] they must be considered in the earliest planning stages of any project. It must first be decided what type of energy will be used and what the probable cost of such energy will be, whether the energy is provided by purchased electric power, engines, or other sources. This paper will deal largely with the most efficient utilization of purchased electric power, however we will note briefly some of the considerations necessary in evaluating engine driven units. More detailed discussions have been made by Owen[2] and others.

Engine driven units. With engine driven units, fuel is often not considered a major cost item. However, it cannot be neglected and must be realistically priced to the operation at the true market value of such fuel. In engine installations, initial investment is usually the major cost item. This investment can partially be offset by salvage value. However, this salvage value must first be realistic and, second, it must be discounted at a rate appropriate to the value of money to the individual concern. Six percent would seem to be about the lowest discount value acceptable today. Likewise, any future savings of engine operation over purchased electric energy should be discounted to be realistic.

The matter of maintenance and operating personnel required is often underestimated. Maintenance costs should be based on dollars per horsepower-year instead of the number of major overhauls that may be estimated for the unit. Maintenance is made up of many relatively small but time-consuming and expensive items as well as major overhauls. Values of $5 to $15 per brake hp per year have been used. A realistic value for the average company is about $10 per brake hp-year.

In considering operating personnel, the cost of payroll, equipment, expenses, and administration for a single employee capable of operating an engine plant of any size is a minimum of $8000 to $10,000 per year. If present personnel are to be used, their time spent in extra operation and maintenance of engine units must be charged to the operating costs if we are to arrive at realistic cost figures.

Purchased Electric Power

Convenience and flexibility of purchased electric power has a definite value depending on the operation and often can be evaluated in dollars and cents. In planning for best utilization of purchased electric power, we must consider these factors:

1. Location of all loads, both present and future.
2. Energy requirements of each load, both present and future.
3. Electric power source, phase, voltage, and capacity.
4. Best utilization voltage for the installation.
5. Design and cost of the necessary distribution lines, transformer banks, switches, etc.
6. Proper types of electric motors, and load evaluation.
7. Rate selection and evaluation.
8. Overall costs of using purchased electric energy for the life of the project.

Determination of loads. The determination of the location and size of all loads both present and future is not easy. Present loads are readily located, but their future size may be indefinite. Future loads are often indefinite both as to size and location, but a careful estimate based on the best information available must be made. The entire operating cost of the project, both present and future, depends upon this estimate. When location and size of future loads are doubtful, the distribution system design must be as flexible as possible so that future loads may be accommodated as inexpensively as possible.

Determination of the size and energy requirements of each load may not be easy. The design engineer must determine present loads accurately and estimate future loads from the projected production history of the field. Such estimates should be made as carefully as possible, and in as much detail as is consistent with the overall plan of the operation. The overall energy cost for the life of the project will

be largely determined by how good these estimates are. This estimate will affect equipment sizing, distribution line design, and rate selection and operating costs.

Electric power source. Electric power source and type are important to planning. It is not enough to contact a local utility and ask for service at the last minute. The electric service problem should be discussed in detail with the power company early in the planning stages of the project. The utility knows its own problems but likely not yours. The utility nearest to your operation may or may not have the capacity or the type of electric energy readily available at the points you may desire it. For example, the utility may have only a small capacity single-phase line available to the operation. To bring in a three-phase line with the capacity required might cost too much and, as a general rule, the operator pays this cost either in direct cash outlay or in high minimum billing guarantees. In some cases there is more than one utility that can serve the installation. The operator certainly should select the one offering the best service and rates.

Selection of the most advantageous point of service is important. Often, selection of the proper point of service can materially reduce the construction costs of the operator. As a general rule, service points are selected so that the distribution system construction costs are held to a minimum. In the case of a large centrally located load, service is usually taken at this point to minimize line losses and to reduce construction costs. Where loads are widely spaced, the point of service should be located near the center of the combined loads.

The saving possible by proper location of the point of service was clearly demonstrated on a recent project evaluated by the author. A system to supply several salt water transfer pumps was originally designed by the electrical contractor with a primary line and two transformer banks plus the secondary line at a cost of $15,000. By moving the point of service to the center of the load, the primary line and transformer banks were eliminated, thereby saving $5000.

The utilization voltage selected will have a strong bearing on the overall first cost and the operating cost of the project. Voltages commonly used for a three-phase installation are 440, 762, and 880 v. Higher voltages have been considered for special installations, however they are not in common use today. There have been several excellent papers published on this subject giving the detailed information necessary for the design and evaluation of three-phase systems at these voltages.[3]

As a general rule, a complete three-phase installation at one of the utilization voltages suggested above is more economic and flexible than a single-phase installation. The higher price of single-phase motors above 1½ hp more than offsets any extra line cost, and in most cases construction costs are less at the higher utilization voltages. There are many fields, however, that are located beyond a reasonable economic reach of the three-phase power lines of the electric utility company but are close by adequate capacity single-phase lines.

For single-phase installations, 110-v power is usually used for lights and loads up to 1 hp, and 220-v power is used for loads above 1 hp. This is a satisfactory utilization voltage in a plant or an operation where all loads are relatively close to the transformer bank. However, for widely separated loads, all served through the same meter, 220-v is usually not a satisfactory service voltage. For installations with widely separated loads, 440-v is a much more favorable voltage both from the line construction cost and the operating standpoint.

A quick, overly-simplified example will show the advantages of the 440-v utilization voltage. Consider a group of several single-phase motors, all supplied through the same meter and served by secondary lines at either 220 or 440 v. In designing the lines for this installation, we find that in order to stay within permissible voltage drops and reasonable construction costs at 220 v, the distance of the longest secondary line can be only 1000 ft. If we maintain the same load and percent voltage drop on this secondary, we find that this distance can be increased to 4000 ft with 440-v. In terms of load-carrying capacity, for the same length and size of secondary line, 440-v will carry four times the load that 220-v will at the same percentage voltage drop.

220 vs 440. The economics of 220-v vs 440-v single-phase distribution systems is shown in an 11-well secondary installation designed for a small field where three-phase service was not available. If 220-v had been used, the cost of lines and transformers would have been $1600. On the other hand, by using 440-v, the cost was only $800. This cost does not include the motors and controls. Since 220/440-v motors are competitively priced with 110/220-v and the same control equipment may be used, the cash saving of using motors on 440-v single-phase in this field was $800. In addition, operating costs will be lower on 440-v because the line losses are only 25 percent of the 220-v line losses for the same load.

Because of limited demand, only a few manufacturers supply 220/440-v single-phase motors on regular order. As more operators work toward reduced purchased electric power costs, 440-v single-phase motors will become more popular.

In fields with several separately metered installations, one of the most effective methods of reducing power costs is consolidation of as many loads as possible on a single meter. As pointed out above, the cost of consolidation with 220-v single-phase motors can be twice the cost of 440-v motors. This unnecessary increased cost makes consolidation uneconomic in some cases.

There are available on the market today "three-phase converters" which are designed for utilization with single-phase power and three-phase motors. Field reports indicate that these converters do a reasonably satisfactory job as long as load and operating conditions do not change appreciably after the unit has been installed and properly balanced electrically. For 110/220-v operation, the price of the converter and three-phase motor is competitive with that of the single-phase motor. At 440-v, the cost of the converter and three-phase motor is considerably more than that of the single-phase motor. In addition, as pointed out above, 220-v is an undesirable utilization voltage where the loads are spaced at an appreciable distance.

Operating cycles. The operating cycle of the installed loads gives a measure of the maximum load that may be expected on the system at any one time. It is not satisfactory to add up all of the installed or to-be-installed horsepower ratings and then design the system for such a total load. In any installation, it is unlikely that all of the motors will ever operate at full rated horsepower. Take, for example, an 80-hp load. A 75-hp motor would be too small for this load, so a 100-hp motor would be recommended. In considering the line design for this motor, we should use 80-hp rather than the 100-hp under normal circumstances.

As another example, consider 10 pumping wells requiring 11 hp each. Fifteen-horsepower motors would be installed on these wells, but the total load required of the distribution system would be 110 hp. In operation, it is unlikely that all 11 of the wells would require their maximum 11 hp at the same time. If we take a load diversification factor of 80 percent, we have a load on the system at any given instant of only 88 hp. However, if we designed on the basis of 150 hp, we would be 78 percent overdesigned. This overdesign costs money.

Voltage drop. We have seen that for any but the closest spacing of loads, the higher utilization voltages are usually the most desirable from both

a cost and operating standpoint. In actual distribution line design, the utilization voltage selected will control the line conductor size for a given load. The conductor size is controlled by the load, the maximum allowable voltage drop selected, and the transformer regulation. Maximum voltage drops used for oilfield distribution lines run from 5 to 10 percent of the motor terminal voltage rating. Voltage drops are determined by the current flowing in the line and the total impedance of the circuit, from the formula: voltage drop = current flowing x total impedance. There are several good manuals available which give considerable detail on distribution line design.[4,5]

Power factor. The power factor of the system will affect the amount of current required and, thus, the required size of the conductors. In addition, some electric rates impose a penalty for low power factor. The type of induction motors usually used in oilfield installations have a low power factor when operating at partial loads. This requires higher current and a larger conductor, not only increasing the cost of the initial installation but also operating costs because of higher line losses. In installations where power factors below 80 percent are anticipated, switching with load condensers is usually installed for power factor correction.

Distribution system. Aluminum steel reinforced conductors (ACSR) are most commonly used for oilfield distribution line construction. Allowable sag and tension in these conductors is governed by the severity of the weather conditions anticipated in accordance with specifications of the National Electrical Safety Code.[6] This code specifies sag and tension standards for light, medium, and heavy weather loading. The height of the distribution poles selected will control the actual length of the spans which may run from 300 to 660 ft, depending on pole height and weather loading.

Transformer bank design depends on primary and secondary voltages, operating load, and power factor. Transformer bank capacity in Kva is equal to:

$$\frac{\text{operating hp} \times 0.746}{\text{power factor}}$$

Here again we must properly evaluate the operating cycle to eliminate overdesign or severe damage from underdesign. Transformer regulation design characteristics are discussed in detail in Reference 4.

In designing lines, both secondary and primary, adequate lightning protection must be installed to eliminate expensive damage and costly repairs. Switches should be installed so that sections of line can be disconnected for minor repairs or changes without having to kill the entire circuit at the primary disconnects.

System flexibility. As a final consideration of oilfield distribution line design, every effort must be made to make the system as flexible as possible so that future loads or changes in existing loads can be handled with a minimum of new construction or costly rebuilding of existing lines to obtain adequate capacity. A little extra conductor capacity in the initial installation costs much less than rebuilding to take on added loads.

There are many excellent electrical contractors in the field. However, many of these people are not set up to design electrical systems and as a general rule do not particularly seek distribution design business. It can be an expensive imposition to ask these people to install your distribution lines without furnishing them a proper design. These people do not have access to the detailed information necessary to plan for the entire life of the project. This lack of information can increase the cost of the project considerably both in first cost, in rebuilding, and in everyday operating cost.

Electric Power Rates

Determination of the proper electric rate will be the governing factor in maintaining the lowest electric energy cost for the life of the project. Electric rates may be divided into three general types: (1) straight energy rate, (2) demand plus energy rate, and (3) load factor rate.

Straight energy rate. In the straight energy rate, the charge is based solely upon the number of kilowatt-hours of energy used. These rates have a high charge for the first few kilowatt-hours, gradually scaling down to smaller charges per kilowatt-hour as the consumption is increased. A typical schedule would be:

$1.00 for the first 12 kwhr or less
4.25¢ per kwhr for the next 108 kwhr
3.25¢ per kwhr for the next 880 kwhr
1.50¢ per kwhr for all additional

This type of rate is used for small operations with relatively small energy consumption.

Demand plus energy rate. In the demand plus energy rate, a charge is made for energy at either a flat rate per kwhr or at a downward-scaling rate such as the straight energy rate. In addition, there is a demand charge, usually based on a measured kilowatt demand. In some rates the demand is based upon horsepower rating of the motors installed or some value agreed to between the consumer and the electric company. The measured demand is the maximum kilowatts of power used during any 15-minute or sometimes 30-minute period in the month. In this type of rate, the energy charges are usually lower than in the straight energy type of rate.

A typical demand and energy rate is:

Demand:
$45.00 for first 15 kw demand or less
$1.80 per kwh for all additional

Energy:
1.5¢ per kwhr for the first 3,000 kwhr
1.1¢ per kwhr for the next 22,000 kwhr
0.9¢ per kwhr for all additional

Load factor rate. In the load factor rate there may or may not be a demand charge as such. Energy charges are based on kwhr consumed per kw of demand. The resulting rate becomes purely a load factor rate in that the higher the load factor, the lower the unit cost in cents per kwhr of energy. In this type of rate, when the total billing is above the minimum, the unit cost of energy in cents per kwhr is governed entirely by the load factor. For example, if an operation had a 65-percent load factor, the unit cost of energy would be the same regardless of whether the demand were 10 kw or 1000 kw, or whether consumption was 1000 kwhr or 100,000 kwhr.

A typical load factor rate is:

$1.35 per kw demand
2.5¢ per kwhr for the first 50 kwhr/kw demand
1.5¢ per kwhr for the next 100 kwhr/kw demand
1.0¢ per kwhr for all remaining kwhr

In many demand plus energy and load factor rates, the customer is penalized when the power factor falls below some specified value, usually 80 percent. This penalty is usually on a percentage basis and many times increases the power cost much more than enough to pay for the necessary condensers to correct the low power factor.

There is no hard and fast rule by which we can determine which of these types of rates may be available or best for a given installation. The operation of each installation must be analyzed and the best rates determined based on careful estimates of kw demand and kwhr consumption. It is not uncommon to find that your operation is different from other operations that the utility has served in a specific area and that they do not have suitable published rates. In such cases it is necessary to negotiate a rate which would give a reasonable cost of purchased electric power for the life of the project.

Selection of rate. When comparing rates it is not necessarily important what the cost of the last energy step is or how the various factors of demand charges and energy charges are set up. The important point is the total average unit cost to the operator in cents per kwhr for the energy consumed. This fact is sometimes overlooked when considering different rates. Just because the lowest energy step on a rate may be 0.8 cents per kwhr, it does not follow that this is

the best rate. The true rate under any condition is the average unit cost of the energy used.

When planning an increase or decrease in the load or a marked change in the operating conditions, then the manner in which the rate is put together is of the utmost importance. On straight energy rates, added load reduces the unit cost and decreased load increases this cost.

On the demand plus energy rate, the unit cost is reduced if load is added and the load factor remains the same or is improved. If load is added and the load factor is reduced, the unit cost may or may not be lower. The unit cost is increased when the load is reduced and the load factor remains the same or is reduced.

In the load factor rate, the unit cost of energy remains the same as long as the load factor is unchanged.

Contracts. After operating conditions are determined and best rate selected, it may be necessary to negotiate a service contract with the electric company. Such contracts usually set minimum billing and/or a minimum demand. As pointed out above, it is not satisfactory to add up the ratings of all the motors in an installation and use this total for the true demand load. Such a procedure can give a billing demand two to three times the actual measured demand.

The operating cost history of a water flood plant with a water well and several pumping wells connected points up the value of properly negotiated contract minimums. In this plant it appeared that the demand would be about 75 kw, even though the total connected load equaled 150 kw. The electric utility company recommended that the full value of 150 kw be used. A compromise of 100 kw was finally set as the minimum demand. After 30 months of operation, this installation had finally worked up to 80 kw which is the maximum load that is expected for the life of the project.

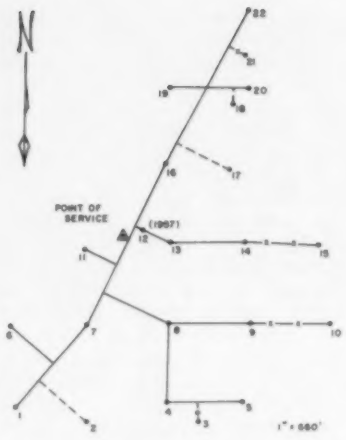
These differences in contract demand amount to a sizeable operating cost figure. This plant is on a pure load factor rate with the true cost of each kw of demand being $3.15. The difference in electric cost between 75 and 100 kw demand amounts to $78.75 per month for a total of $2362.50 for the 30 months when the demand was below 75 kw. The overcharges are now $63 per month for 20 kw. Since the existing contract has 30 months to go, the future overcharges will be $1890. The total spent for unused power for the term of this contract will be $4252.50. If the power company recommendation of 150 kw had been taken, an additional $157.50 per month, for a total additional charge of $9450, would have been spent. This would have brought the total overcharges for unused power to $13,702.50 for the 5-year term of the contract.

Another plant studied has been paying for 150-kw demand on a slightly lower load factor rate for several years and the demand has never exceeded 100 kw per month until recently. This has amounted to an excess demand charge over a contract period of 5 years of $6115. In summation, we may say that the determination of electric power contract terms is important and should receive the most careful consideration.

Is it any wonder that purchased electric power costs seem excessive for some fields? These are not isolated examples, but are typical of many fields today where power costs are excessive due to faulty planning and failure to give closest attention to all of the details involved in use of purchased electric power.

Another aspect of electric power contracts is the duration of the contract. It is advantageous for the operator to obtain as short a term contract as possible. It is realized that the utility company must protect itself over a certain period of time to give it reasonable opportunity to pay out any investment it may make in servicing a customer. Nonetheless, the operator must make every effort to obtain as short a contract as possible because operating conditions are always subject to unexpected changes and a long-term high-minimum contract can make production costs excessive.

We have mentioned briefly the desirability of consolidating as many loads as possible on a single meter and have discussed the usually advantageous effect of increased consumption through a single meter. The question arises as to when is it best to consolidate loads on a single meter. As a general rule, the loads should be consolidated on a single meter as early as possible in the life of a field. This is especially true of waterfloods where it is known that the fluid volume of the wells will increase in a definite pattern as the flood progresses. In the initial stages of a field, particularly in a waterflood, it often appears of doubtful economic value to build the necessary distribution lines to consolidate the entire load on a single meter. The savings are usually slight and the investment cost appears high in relation to such savings. As the production from the field increases, existing loads increase, and more loads are added, the investment gradually appears more attractive until at last it becomes obviously economical to consolidate all loads on a single meter. Quite often we can then say in retrospect that if we had consolidated all loads on a single meter in the early stages of operation, a considerable overall saving in the cost of operating the field would have resulted.



FIELD A

ELECTRIC DISTRIBUTION SYSTEM FOR 3-PHASE, 440-V OR 1-PHASE, 440-V PLANS

Wells connected in 1956 (14)
Wells connected in 1957 (4)
Wells connected in 1958 (3)
Wells connected in 1959 (1)

FIG. 1. **Electric distribution system** shows the orderly and progressive installation of customer-owned secondary power lines.

Since the fluid production from a field is predictable with reasonable accuracy, we may likewise predict the electric consumption with the same accuracy. And from that prediction we can tell what the overall electric cost of the field will be. This analysis will show, as a general rule, that consolidation of all loads on a single meter is desirable eventually, and it will also show that at some time reasonably early in the life of the flood the necessary construction to place all loads on a single meter is justified. Early consolidation of electric loads takes full advantage of all savings for the life of the project. Any savings not obtained by early consolidation are lost and can never be retrieved.

Study of an Actual Field

Many of the ideas considered in the preceding paragraphs are rather clearly illustrated in a small waterflood project in Oklahoma which we shall call Field A. This waterflood was started in 1955 and the first well was electrified early in 1956. The costs presented are based on actual operating figures through September 1959, and are estimated through 1964 based on the ultimate recovery and depletion of the field.

In the electrification of this field, no consideration was given to an overall

TABLE 1. Investment and Energy Costs for Four Plans of Electric Energy Utilization in the 26-Well Field A.

		1956	1957	1958	1959	1960	1961	1962	1963	1964
PLAN A — Install 1-Phase, 220-v Equipment on Individual Meters at Each Well.										
Annual Cost	Motors and Controls	7,300	2,090	1,565	522	—	—	—	—	—
	Energy Cost	509	1,828	5,428	6,990	6,040	5,530	4,700	2,670	1,410
	Total Cash Outlay	7,809	3,918	6,993	7,512	6,040	5,530	4,700	2,670	1,410
Cum. Cost	Investment	7,300	9,390	10,955	11,477	11,477	11,477	11,477	11,477	11,477
	Energy Cost	509	2,337	7,765	14,755	20,795	26,325	31,025	33,695	35,105
	Total Cash Outlay	7,809	11,727	18,720	26,232	32,272	37,802	42,502	45,172	46,582
PLAN B — Install 3-Phase, 440-v Equipment and Secondary Lines Needed to Serve All Loads from One Meter.										
Annual Cost	Motors and Controls	5,070	1,450	1,087	362	—	—	—	—	—
	Line Construction	4,136	536	697	72	—	—	—	—	—
	Energy Cost	115	685	2,430	3,190	2,920	2,475	2,075	1,055	530
	Total Cash Outlay	9,321	2,671	4,214	3,624	2,920	2,475	2,075	1,055	530
Cum. Cost	Investment	9,206	11,192	12,976	13,410	13,410	13,410	13,410	13,410	13,410
	Energy Cost	115	800	3,230	6,420	9,340	11,815	13,890	14,945	15,475
	Total Cash Outlay	9,321	11,992	16,206	19,830	22,750	25,225	27,300	28,355	28,885
PLAN C — Construct Necessary Secondary Lines to Consolidate All Wells on a Single Meter in January 1960, Utilizing Existing 1-Phase, 220-v Equipment on Wells.										
Annual Cost	Motors and Controls	7,300	2,090	1,565	522	—	—	—	—	—
	Line Construction & Transformers	—	—	—	—	4,680	—	—	—	—
	Energy Cost	509	1,828	5,428	6,990	2,920	2,475	2,075	1,055	530
	Total Cash Outlay	7,809	3,918	6,993	7,512	7,600	2,475	2,075	1,055	530
Cum. Cost	Investment	7,300	9,390	10,955	11,477	16,157	16,157	16,157	16,157	16,157
	Energy Cost	509	2,337	7,765	14,755	17,675	20,150	22,225	23,280	23,810
	Total Cash Outlay	7,809	11,727	18,720	26,232	33,832	36,307	38,382	39,437	39,967
PLAN D — Install 1-Phase, 440-v Equipment on Wells and Construct Necessary Secondary Lines to Serve All Wells from a Single Meter.										
Annual Cost	Motors and Controls	7,300	2,090	1,565	522	—	—	—	—	—
	Line Construction	2,809	380	464	53	—	—	—	—	—
	Energy Cost	115	685	2,430	3,190	2,920	2,475	2,075	1,055	530
	Total Cash Outlay	10,224	3,155	4,459	3,765	2,920	2,475	2,075	1,055	530
Cum. Cost	Investment	10,109	12,579	14,608	15,183	15,183	15,183	15,183	15,183	15,183
	Energy Cost	115	800	3,230	6,420	9,340	11,815	13,890	14,945	15,475
	Total Cash Outlay	10,224	13,379	17,838	21,603	24,523	26,998	29,073	30,128	30,658

plan so that purchased electric power could be used in the most efficient and economic manner.

As the individual wells were taken off of the existing central power, they were placed on 220-v single-phase motors with each well served on a separate meter set by the local utility company. There were 14 wells connected in 1956, 4 in 1957, 3 in 1958, and 1 in 1959. Fig. 1 shows how the secondary lines could have been constructed in an orderly and progressive manner if it had been decided to install customer-owned secondary in the earliest stages of the flood.

Four plans. In this problem, we have considered four separate plans. In Plan A, we have the field as it has been operated. Plan B considers installation of three-phase motors and the distribution lines necessary to serve all wells from a single metering point as shown in Fig. 1. Plan C will be accomplished in 1960 by constructing the necessary distribution lines and placing all wells on the same meter using existing 220-v single-phase equipment. Plan D considers installation of 440-v single-phase motors initially and construction of the single-phase secondary system.

Investment and energy costs. Table 1 shows the cash outlay necessary in each case for capital investment in motors, controls, and lines, and the electric energy costs. Electric energy consumption is based on actual energy consumed through September 1959, and estimated thereafter on a basis of anticipated recovery and ultimate depletion in 1964. Electric energy costs for Plan A are based on actual billings through September 1959, and estimated thereafter. Other energy costs have been determined from an actual power rate available from the utility company. A cumulative total is carried for each year for capital investment and energy costs.

Capital investment and energy costs are shown in Fig. 2, and the total yearly cash outlay for each plan is shown in Fig. 3.

It is obvious that Plan A, placing all of the wells on individual meters, is by far the most expensive plan, requiring a net cash outlay of $46,582. Plan C shows that even though the initial merits of load consolidation may have been overlooked, it is not too late to take advantage of them. In this case, Plan C will reduce the total cash outlay to $39,967 for the life of the field.

Plan B shows the unquestioned merit of placing all of the wells on three-phase 440-v power, served by a customer-owned distribution system in the initial planning stages of the operation. The total cash outlay here is only $28,885 for the life of the field.

Plan D is interesting from the standpoint of field locations that do not have three-phase power available. It gives a total cash outlay of only slightly more than Plan B of $30,658. This additional cost comes primarily from the difference in cost between single-phase and three-phase equipment. Plan D is particularly interesting when compared with the capital investment of Plan C. In Plan C we have all of the wells on 220-v motors, and in Plan D they are on 440-v motors. The capital investment total in Plan D is $15,183, and in Plan C, it is $16,157. In this case, we save $974 merely by using a more favorable secondary voltage.

In making this comparison none of the figures has been discounted. In the event that such a comparison of an installation showed less than such a clear-cut difference in cash outlay, use of discount values consistent with individual company policy would be in order.

As early as 1957, it was apparent from the slope of the power cost curve that in some three to four years, savings could be realized which would pay for the investment of secondary line construction as suggested in Plan C. This is true in many cases and we might expand it into a fairly safe rule. If a waterflood operation will show a pay-out on electric load consolidation at present operating rates and the overall life of the flood is equal to the pay-

out time, such a load consolidation program will in all probability be profitable.

Accurate records. Throughout this discussion we have stressed the need for accurate and up-to-date information if the most difficult utilization of electric energy is to be maintained for the life of any project. From this it naturally follows that some type of records must be kept that will show the full story on electric energy problems both past and present.

Change is the most outstanding feature of the oil business. Rates and operating conditions that were satisfactory yesterday are out of date today. As an oil reservoir changes, so the energy needed to produce this reservoir changes. We have previously discussed the importance of obtaining the best rates possible along with the most favorable contract terms. These rates and contract terms that were satisfactory six months ago may be completely unsatisfactory today. We will never know this, however, unless accurate and complete records are kept for this purpose.

Such records need not be elaborate, but they must contain all of the information necessary to check the charges and properly evaluate the operation. These records must continually show the complete information required for the actual billing, and such information as may be necessary for rate comparisons, operations evaluations and checks for proper charges.

These records are an invaluable source of information in planning new installations. By comparing the new operation with similar existing operations, we can better arrive at a realistic evaluation of the necessary design loads, rate selection, and contract terms. We have pointed out above the importance of each of these factors in getting the most energy for the least money.

The dollars and cents savings from up-to-date, complete records of electric energy can be very real. On an operation in Kansas, a large plant had been shut down, but some electric power was still being used on the lease. The lease was on a rate having a minimum billing of $245 per month, even though only a very small amount of energy was now being used. As soon as this high minimum billing showed up, a new rate having a minimum billing of $29 per month was negotiated. Immediately thereafter all operation on the lease was discontinued. Since the electric contract still had 11⅔ months to run, the operator was obligated for minimum billing for this period. At the original rate, this would have been $2858 instead of the actual charges made of $338. The savings of $2520 made by changing the rate as soon as the need showed up on the records was well worth the cost of keeping the records.

In another field there were several wells placed on a one-year contract with a $20 per month minimum billing. This minimum was well in excess of the cost of energy used and was made to justify the utility company's cost of furnishing service. At the time that adequate records were started on this field, the initial term of the contract had been expired for two years. If adequate records had been kept all

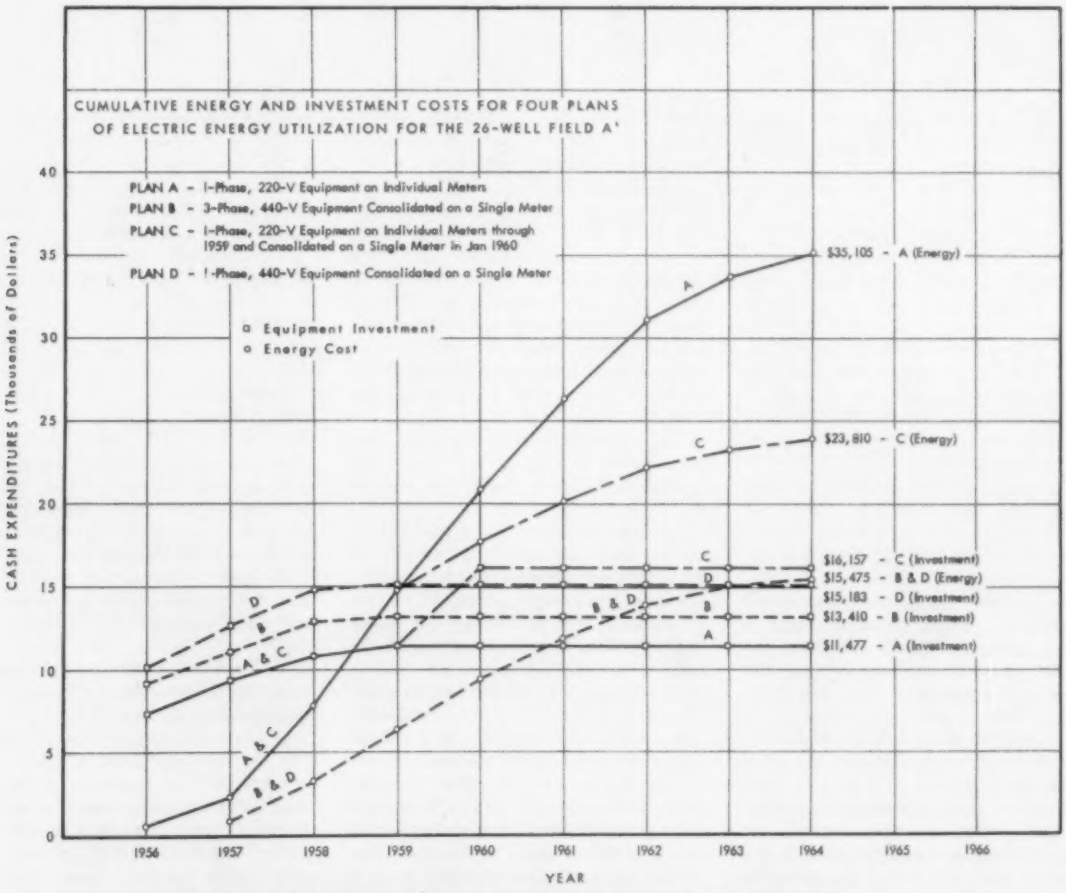

CUMULATIVE ENERGY AND INVESTMENT COSTS FOR FOUR PLANS OF ELECTRIC ENERGY UTILIZATION FOR THE 26-WELL FIELD A'
PLAN A - 1-Phase, 220-V Equipment on Individual Meters
PLAN B - 3-Phase, 440-V Equipment Consolidated on a Single Meter
PLAN C - 1-Phase, 220-V Equipment on Individual Meters through 1959 and Consolidated on a Single Meter in Jan 1960
PLAN D - 1-Phase, 440-V Equipment Consolidated on a Single Meter
Equipment Investment
Energy Cost
CASH EXPENDITURES (Thousands of Dollars)
YEAR
$35,105 - A (Energy)
$23,810 - C (Energy)
$16,157 - C (Investment)
$15,475 - B & D (Energy)
$15,183 - D (Investment)
$13,410 - B (Investment)
$11,477 - A (Investment)

FIG. 2. Capital investment and energy costs are plotted in order to determine the most economical of four proposed electrification plans for a typical 26-well field.

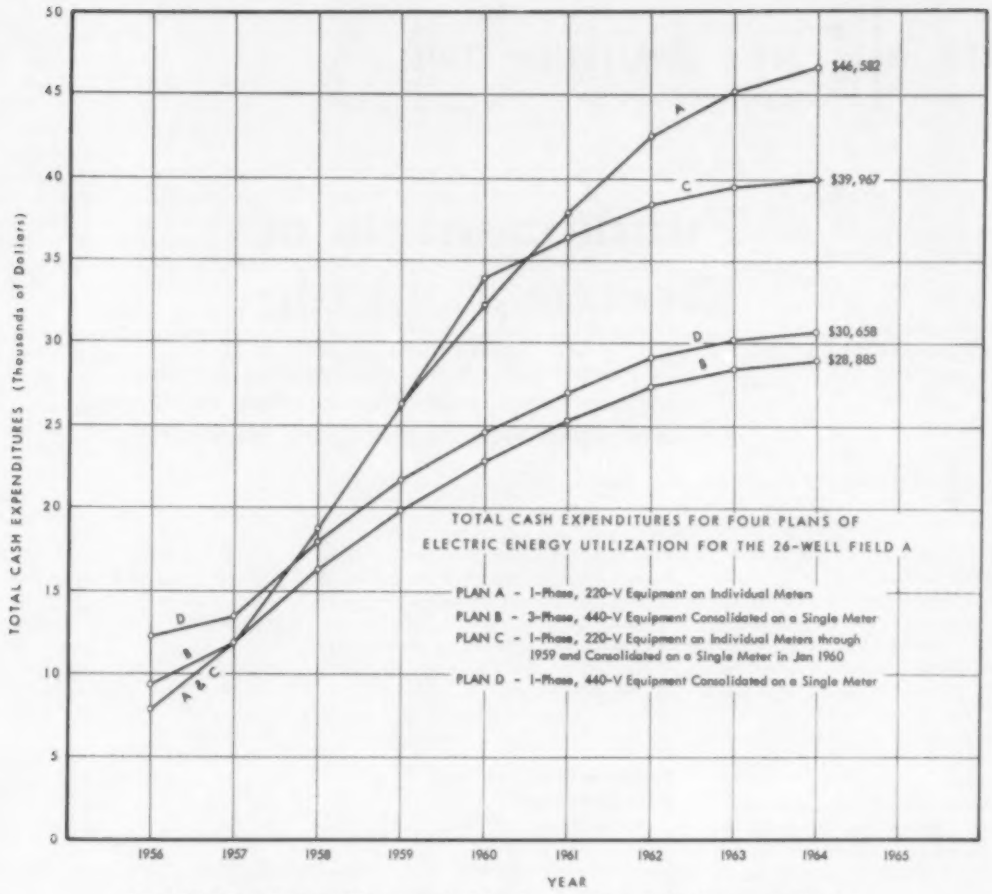

TOTAL CASH EXPENDITURES (Thousands of Dollars)
YEAR
TOTAL CASH EXPENDITURES FOR FOUR PLANS OF
ELECTRIC ENERGY UTILIZATION FOR THE 26-WELL FIELD A
PLAN A - 1-Phase, 220-V Equipment on Individual Meters
PLAN B - 3-Phase, 440-V Equipment Consolidated on a Single Meter
PLAN C - 1-Phase, 220-V Equipment on Individual Meters through 1959 and Consolidated on a Single Meter in Jan 1960
PLAN D - 1-Phase, 440-V Equipment Consolidated on a Single Meter
$46,582
$39,967
$30,658
$28,885
A
C
D
B
A B C

FIG. 3. **Total cash expenditures** required for the four plans of electric energy utilization show that the favorable plan calls for 3-phase, 440-v equipment consolidated on a single meter.

along, and periodically evaluated, two-year savings as high as $326 per well could have been made by cancelling the high minimum contract as soon as it expired.

These two examples are not isolated cases, but are typical of many oilfield installations. They point up very clearly the actual dollars and cents value of accurate, up-to-date records of electric energy and periodic evaluation of these records.

An electric power meter is one of the best checks we have on field operating conditions. It is completely unbiased and not subject to guesses or preconceived notions as to what operating conditions may be. Careful analysis of the information furnished on the electric bill gives an invaluable and sometimes startlingly true picture of what is really going on in the field. Changes in electric energy consumption indicate changes in field operation and often give the home office a preview of important changes in operations that are occurring. The electric meter information can be used to determine whether or not everyday operations are being carried forward as planned.

A good example of this occurred recently in a shallow field in Oklahoma. The engineering department had determined that for best production one of the wells should be pumped 5 hr a day. The electric bill for this well showed that 1029 kwhr had been consumed at a cost of $33.43. Converting this consumption back to probable hours pumped, it was apparent that the well had been operating close to 24 hr per day. Upon investigation it was found that the well had actually been pumping 24 hr per day because the pumper had misunderstood the instructions. The next month, the bill was down to 206 kwhr for $8.88 when pumping the prescribed 5 hr per day. Without proper electric records, the 24-hr pumping might have continued for months at an excess cost of $24.55 per month.

Conclusion

In the final analysis, the cost of purchased electric power is often just about what the operator makes it. By careful planning and periodic evaluation, electric power costs will be favorably competitive with other sources of energy. With inadequate planning and failure to review the problem periodically, electric power costs have a hard time competing with costs of other types of energy. Electric power properly managed and utilized is a useful and powerful servant. Unmanaged and unwatched, it can be an expensive luxury that few in the oil industry can afford.

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MODERN WELL COMPLETION SERIES

PART 4

Fundamentals of Electric Logging

Developments in electric logging practices provide data needed for location, evaluation, and production of petroleum reservoirs

W. P. Biggs, *Schlumberger Well Surveying Corporation, Houston, Texas*

ELECTRIC LOGGING SERVICES are designed to economically provide geologists and petroleum engineers with data they require for the location, evaluation, and production of petroleum reservoirs. From a rather obscure beginning in France, a quarter of a century ago, the simple electrical survey has fostered a large family of technical services that are run on electrical cables.

As well logging techniques improved, the art of interpreting the available data became more advanced. Today the logs are used for correlation, depth control, identification of productive zones, and for the quantitative evaluation of reservoirs.

The Electric Log

A section of an electrical log is shown in Fig. 1. The log is divided into three recording tracks. The single track on the left side of the log contains a continuous recording of the spontaneous potential (SP) curve. The two tracks on the right contain the resistivity curves. Each curve shows a sequence of peaks, deflections, and flat zones that are representative of the formations penetrated. The depths, in even hundreds of feet, are printed in the otherwise blank column, near the left center of the log.

The horizontal lines on the log are depth lines. In this case the space between two lines represents ten feet of hole. Note that the 50-ft and 100-ft depth lines are heavier than the intermediate 10-ft lines. Logs are normally recorded on a 1 in. = 100 ft or a 2 in. = 100-ft scale. In addition, a detailed scale of 5 in. = 100 ft is employed through potentially productive horizons.

To the untrained eye the meanderings of the recorded curves mean very little. It is well to remember that the electrical log investigates only those basic formation properties to which it is sensitive. The conversion of log data into geological or reservoir information depends upon a sound understanding of the factors that affect the responses of the logging devices. Though extremely simple in concept, the art of log interpretation is very complex.

Fundamentals of Log Interpretation

While the electric log is utilized for the determination of lithological changes and such properties as fluid saturation, porosity, etc., it must be remembered that the language of the log is electrical. A proper translation must therefore be based upon an understanding of the electrical terms that are encountered. The first such term is resistivity.

Resistivity. Resistivity is an expression of the difficulty with which electrical current flows through a substance. By definition, the resistivity of a sub-

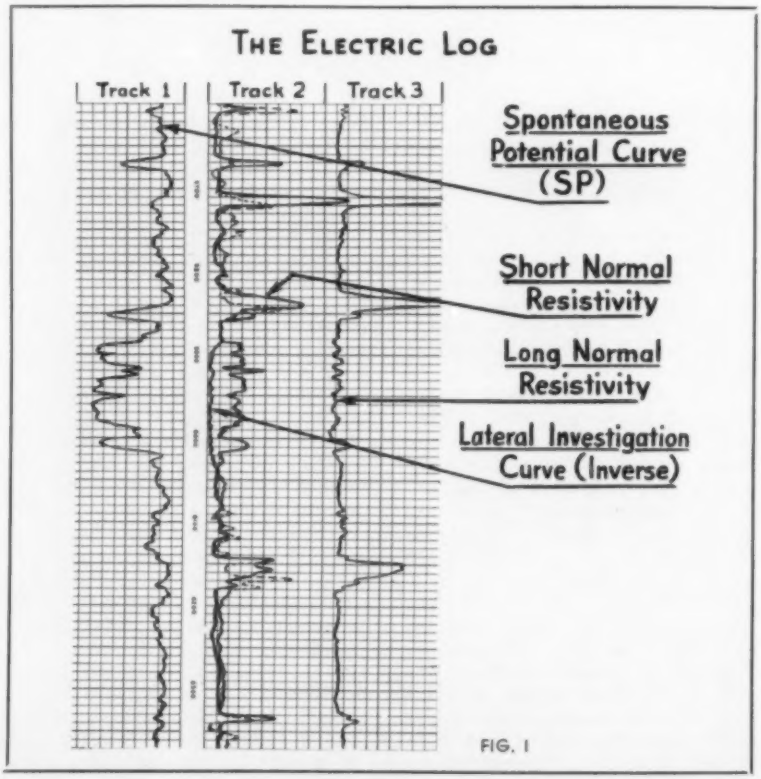


FIG. 1

stance is the electrical resistance, at a given temperature, encountered by a current flowing through a volume of the substance of unit length and unit cross-sectional area.

Resistivity = Resistance/Unit Length/Unit Area.

In electrical logging the unit of resistance is the ohm, the unit of length is the meter, and the unit of area is the square meter. Therefore, the unit of measure for resistivity is the ohm/meter/meter^2, or the ohm-meter.

Resistivity is a specific property of a substance. It is independent of size or shape. For example, it is well known that glass, rubber, and air are good electrical insulators — they have very high resistivities. On the other hand, metals are used to transmit electrical current because they have very low resistivities.

The resistivity of water is variable. It depends upon the concentration of dissolved salts present in the water and also upon the temperature of the solution. The greater the concentration of dissolved salts, the lower the resistivity of the solution. In other words, salt water has a much lower resistivity than fresh water. The resistivity of the solution decreases with an increase in temperature — hot water is less resistive than cold water.

The resistivities of solutions are very important in well logging. The solutions within the earth primarily determine the resistivities of the formations since most of the solid portions of the earth are nonconductive when dry. Essentially then, we are measuring the water in the formations when we record resistivities.

The two most important factors that determine the resistivity of a formation are the type and the amount of water that it contains. The type of water, electrically speaking, is its resistivity. Resistivity depends upon salinity and temperature. The amount of water that a formation contains depends upon the porosity of the zone and upon the relative percentage of the pore space that is filled with hydrocarbons.

To illustrate the relationship between the resistivity and the porosity of a formation, we will first consider a unit volume of water. The unit volume is represented by a cubical container that has sides one meter long.

If this container is filled with a solution, pass a current through the solution from the front face to the rear, and measure a resistance of one ohm, the resistivity of the unit volume is one ohm-meter. In this case the porosity of the unit volume is 100 percent since there are no solids within the volume.

If sand grains are added to the unit volume part of the water is displaced. The porosity of the unit volume will be reduced. At the same time the resistivity will increase. Only the water conducts the electrical current and, although the resistivity of the water itself remains the same, the resistivity of volume as a whole is increased.

The porosity of the volume could be further reduced by the addition of smaller grains that would fit within the space left by the larger grains. Any such reduction of porosity would result in less water and would therefore lead to a higher resistivity.

Suppose that the resistivity of the unit volume was now found to be 10 ohm-meters. Note that this is 10 times the resistivity of the water that is contained within the pore spaces.

If we now completely remove all of the 1 ohm-meter water, without disturbing the sand grains, and replace it with water of .1 ohm-meter resistivity, we will measure a resistivity of 1 ohm-meter. The ten-to-one ratio between formation and water resistivities remains intact. This ratio is referred to as the formation resistivity factor, F. The formation factor is a property of the rock matrix; it is independent of the fluid contained.

The resistivity of the volume in this case is called R_o. By definition, R_o is the resistivity of a formation when it is 100 percent saturated with formation water of resistivity R_w. Thus, the expression for formation factor is:

$$F = \frac{R_o}{R_w}$$

The addition of sand grains to the unit volume caused the porosity to decline and the resistivity of the volume to increase. Since the same kind of water was present in the unit volume, the resistivity increase was due solely to an increase in formation factor. This relationship provides the basis for an expression relating F and porosity. The expression is:

$$F = \frac{a}{\phi^m}$$

Where F = formation factor
ϕ = porosity expressed in percent
a = a constant
m = cementation exponent.

The most commonly used forms of this expression are:

$$F = \frac{1}{\phi^2}$$

(Archie formula — used mostly in limestones.)

and

$$F = \frac{.62}{\phi^{2.15}}$$

(Humble formula — used mostly for sands.)

Effect of hydrocarbon saturation. Both oil and gas are nonconductors of electrical current; they have very high resistivities. Therefore, if a portion of the pore space is filled with oil the formation resistivity will be higher than if only water were present. An empirically derived expression of this relationship is as follows:

$$R_t = \frac{R_o}{S_w^n}$$

Where R_t = resistivity of formation containing both oil and water.
S_w = percent of pore space filled with water.
R_o = resistivity of formation if 100 percent water saturated.
n = saturation exponent.

The saturation exponent, n, was found to vary between 1.7 to 2.2, depending upon the type of formation. Experience indicates that considering n = 2 will afford saturation determinations well within the accuracy with which the various parameters can be measured.

Since the value R_o is rarely available for a particular zone of interest, it is necessary to build a value based upon the formation factor and the R_w. Since $F = R_o/R_w$; $R_o = FR_w$. The expression for R_t can then be stated in a more useful form:

$$R_t = \frac{FR_w}{S_w^2}$$

Considering $F = 1/\phi^2$, this expression may be further modified to:

$$R_t = \frac{R_w}{\phi^2 S_w^2}$$

The above expression sums up factors that affect the resistivity of a clean formation. It will be seen that formation resistivity will vary directly, and linearly, with the resistivity of the formation water. A decrease in either porosity or water saturation, or both, will cause an increase in formation resistivity.

To solve for water saturation the expression may be rewritten as:

$$S_w = \sqrt{\frac{FR_w}{R_t}}$$

Logging Methods

Essentially, the expressions that have been presented constitute the relationships which convert electrical log data to reservoir rock and fluid data. To utilize these expressions we need only the values of R_w, ϕ (or F), and R_t. If the desired values could always be read directly from the logs, quantitative interpretation would be extremely simple. Unfortunately, such is rarely the case.

The log readings can be affected by many variable factors. Among these variables are the size of the borehole, the resistivity of the mud in the hole,

the thickness of the zone under study, the resistivities of the surrounding beds, the invasion of the zone by mud filtrate, and the characteristic response of the particular logging device.

A large family of electrical logging services has been developed to reduce the number of unknown factors in log interpretation. These services are designed to give, as accurately as possible, values for water resistivity, true resistivity, and porosity.

Determination of R_w. The SP curve that is run with most electrical logs serves two main functions. The first of these is to differentiate between potential reservoir rocks and impervious shales. The second is to provide a means of computing the formation water resistivity.

The SP curve is obtained by measuring the potential between an electrode in the well and a fixed reference electrode at the surface (Fig. 2). The resulting curve has a series of anomalies departing from a shale base line. These anomalies correspond to porous and permeable formations. However, the SP curve is not a measure of either porosity or permeability; it is an indicator of the absence of shale and, as such, can be used to locate possible reservoir beds.

The SP results from the ohmic drop in the borehole caused by the circulation of naturally occurring currents. These currents circulate about the sand-shale contacts and are proportional in magnitude to the relative salinities of the formation water and the drilling mud. In other words, the fresher the drilling mud, with respect to the formation water, the greater will be the magnitude of the currents that give rise to the SP anomalies.

Fig. 3 shows the relationship between the SP anomaly and the relative salinities of the formation water and drilling mud. Note that with fresh mud and salty formation water the SP anomaly is to the left of the shale base line. In the opposite case, where the formation water is fresher than the drilling mud the anomaly is to the right. Where the mud and formation water are of equal salinity the SP curve does not depart from the shale base line.

As previously mentioned, the resistivity of a solution is inversely proportional to the concentration of dissolved salts. Therefore, the magnitude of the SP anomaly opposite a clean sand may be used to compute the relative resistivities of the mud and the formation water. This computation is accomplished by means of the following expression:

$$SP = -K \log \frac{R_{mf}}{R_w}$$

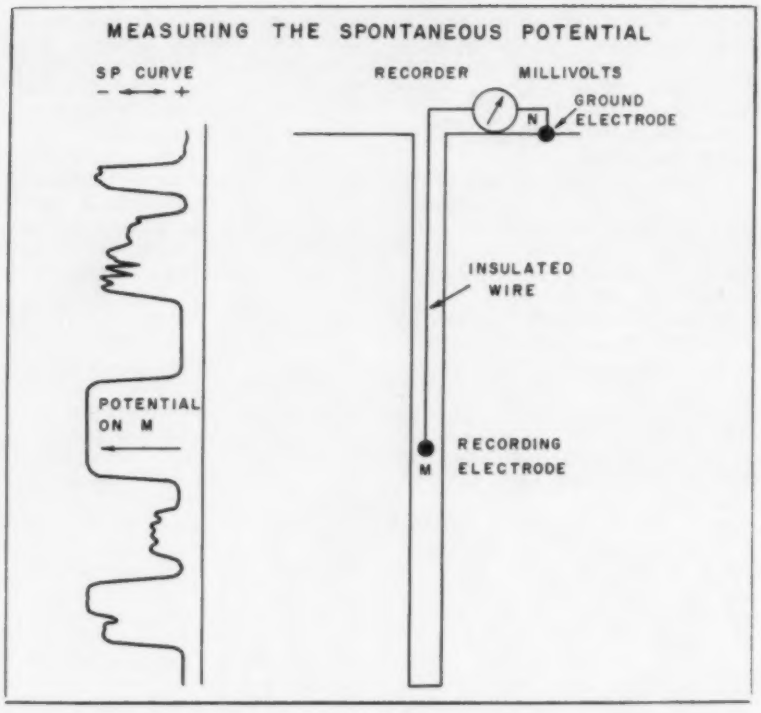
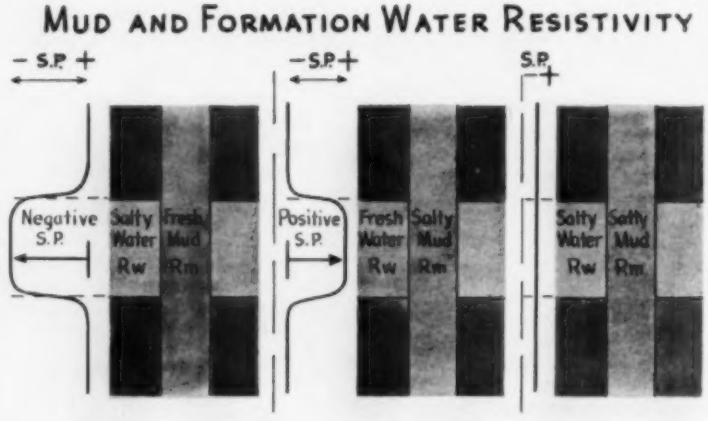


FIG. 2



RELATIONSHIP BETWEEN MUD RESISTIVITY, WATER RESISTIVITY AND S.P.

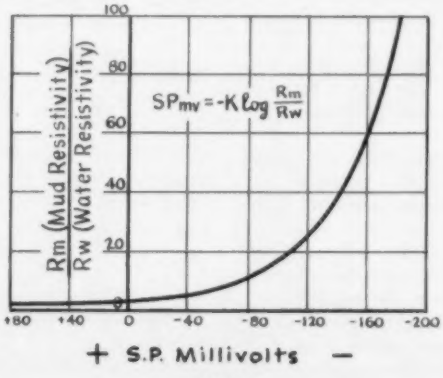


FIG. 3

Where SP = Magnitude of SP anomaly (expressed in millivolts) opposite a clean sand.

K = A constant that depends upon temperature.

R_{mf} = Resistivity of the mud filtrate (the water phase of the drilling mud).

R_w = Resistivity of the formation water.

At the time of logging, a sample of drilling mud is filtered under pressure and the resistivity of the resulting filtrate is measured. The temperature in the well is determined by means of maximum reading thermometers that are attached to the sonde. Thus, with SP, K, and R_{mf} known, the above expression can be solved for R_w.

The complications that arise in qualitative log calculations when the sands under study contain shaly material have been neglected. The presence of shale in a sand is certainly a major complication.

Any appreciable amount of shale in a sand will result in a reduced SP (called a pseudo-static SP or PSP). This will cause an erroneously high value of R_w to be computed. In such a case it would be necessary to compute the value of R_w from a nearby clean sand or to know the R_w from the measurement of samples of water produced from the same geological horizon in a nearby well.

We stated that the resistivity of a formation was simply an indication of the amount and kind of water that the formation contained. A similar simplified explanation of the SP curve can be made. The SP is an indication of the presence or absence of shale and a measure of the relative salinities of the drilling mud and the formation water.

Measurement of formation resistivity. The next parameter that must be determined to calculate the water saturation is the true formation resistivity. Before discussing the manner in which the electrical log is used for the measurement of formation resistivity it will be expeditious to describe the method that is employed in the measurement of mud resistivity.

The mud which is to be measured is placed in a cylindrical rubber cup. A known electrical current is caused to flow from electrode A, through the mud, to electrode B. The resulting drop in potential (due to the resistance of the column of mud) between electrodes M and N is measured. Since the M to N distance and the cross sectional area of the mud column are accurately known, the resistance measured may be converted to resistivity. You will note that we utilize two current electrodes and two measure electrodes.

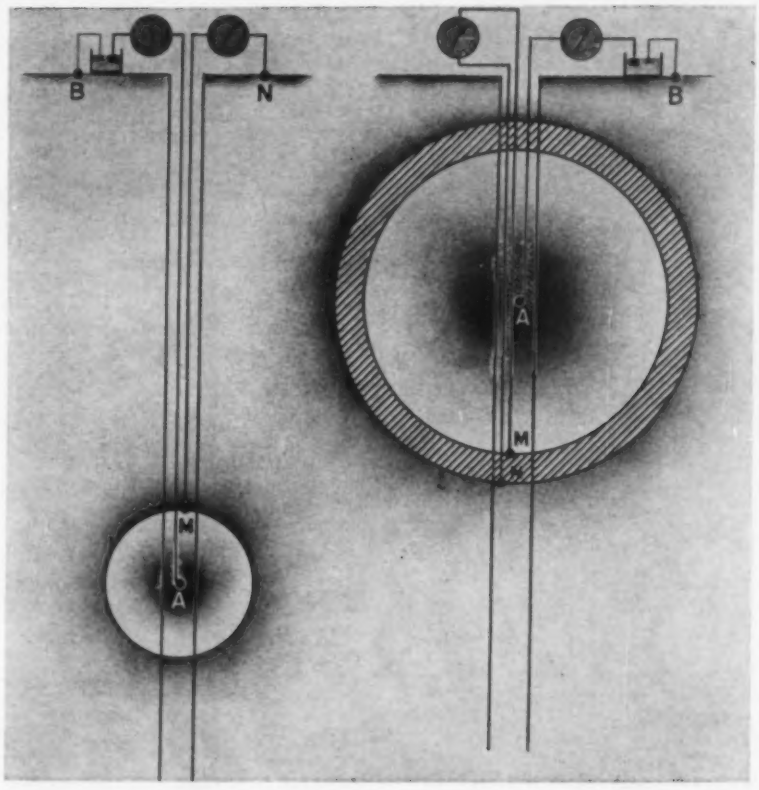


FIG. 4

Resistivity Measuring Devices

The electrical log. This device employs the same method as that used in measuring mud resistivity for the measurement of formation resistivity. A current is caused to flow from one electrode to another. The resulting difference of potential between a pair of measure electrodes is recorded. However, with the electrical logging device our measurements are considerably complicated by the fact that we no longer have an insulated cylinder in which we can confine all of the current. The current, after leaving electrode A is free to take the path of least resistance to B. The potential difference due to this flow of current is measured between M and N electrodes.

Fig. 4 illustrates the two commonly used electrode arrangements. The device on the left, with A and M relatively close to each other and B and N remote, is referred to as a normal arrangement. The device on the right is called a lateral investigation device. In this case M and N are relatively close to each other. The electrical log usually consists of one lateral and two normal electrode arrangements.

The three electrode arrangements are necessary to minimize the effects of bed thickness, of the presence of the borehole, and of the invasion of the formation by mud filtrate. (Fig. 5.)

A normal device is said to have a depth of investigation that is twice the AM spacing. By this we mean that, in a homogeneous medium, 50 percent of the signal will come from a spherical volume centered at the midpoint of the spacing and with a radius equal to twice the AM spacing. The most commonly used normal spacings are the 16 in. (short normal) and the 64 in. (long normal). It can be seen that for a 16 in. normal the zone that contributes the major part of the signal will be a sphere with a radius of 32 in. For the 64 in. normal the radius of the spherical volume will be approximately ten feet.

The greater depth of investigation is necessary to overcome the effects of mud invasion. The invaded zone of a water sand drilled with fresh mud will be considerably more resistive than the noninvaded sand that contains salt water. To be able to distinguish between oil and water sands it is important that we obtain a value of formation

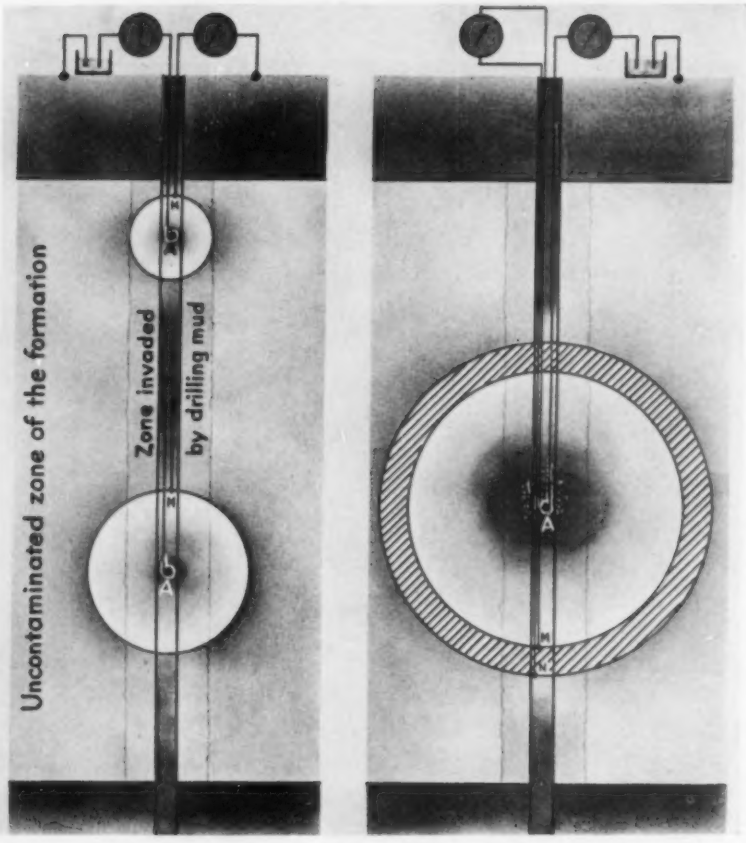


FIG. 5

resistivity that is not severely affected by invasion.

The logical answer would appear to be the use of very long spacings. Unfortunately, however, as the length of the spacing increases the resolution of the device decreases. The curve is flattened considerably. It is necessary that a bed be approximately four times thicker than the length of the AM spacing before the recorded curve can be expected to furnish a proper value of R_t.

Short electrode spacings are necessary even though they have a very shallow investigation. The short normal is used for correlation, for the location of bed boundaries, and for the measurement of resistivity in thin beds. The long normal, with less detail but greater depth of investigation, is used to provide a better approach to R_t in medium thick beds, and to help determine the depth of mud filtrate invasion.

The lateral spacing most often run is approximately 19 ft in length. The depth of investigation of the lateral device is considered to be approximately equal to its spacing. It is therefore the deepest investigating resistivity curve of the electrical log.

However, the response of the lateral is nonsymmetrical. A relatively thick bed is necessary before the resistivity reading will be unaffected by the surrounding beds. For relatively thick beds of uniform resistivity the lateral curve provides the most accurate measurement of R_t.

The electrical log is at its best when used in fresh mud, formations of low to moderate resistivity, and fairly thick beds. Under these conditions the influences of the mud in the borehole and of beds adjacent to the formation are at a minimum. Corrections may be applied to recorded readings to obtain true resistivities.

Focused logging. Focused resistivity logging devices are necessary when beds are thin or when formation resistivities differ greatly from the mud resistivity. Under such conditions the efficiency of the conventional electrical log is severely impaired. The measurements obtained can be seriously affected by the borehole and by beds above and below the zone under study.

To minimize these effects, two types of focused logging systems have been developed; these are induction logging and laterologging. In each, the current is confined so that the recorded signals correspond only to the resistivity of a horizontal disc of limited thickness. As a result, the effects of the mud column and the formations above and below this disc are minimized or completely cancelled.

The two systems of focused logging are quite different in many aspects. The induction log functions in oil-base muds and gas-filled holes where the laterolog and electrical log cannot operate. Under both of these conditions, and when used in fresh muds, the induction log gives values close to true formation resistivity.

The laterolog can be used in both fresh and salt muds but is especially helpful in obtaining formation resistivities in salt muds and in areas where formation resistivities are high. Logs obtained with these two instruments provide the best data for interpretation over the entire range of uncased borehole and formation conditions.

The induction log. The induction log is a focused logging method which requires no current flow from the tool into the formation. Instead, the formations are energized by an alternating magnetic field created by the tool. Since no contact through the mud is required, the induction log may be used to record formation resistivities in empty holes or nonconductive oil-base muds.

The recorded signal of the induction log is less affected by resistive materials within the volume of measurement than by conductive ones. Therefore, the recorded values closely approach true formation resistivities in fresh muds where it is necessary to read beyond the invaded zone.

With the induction log the basic reading is the conductivity of the formations. Conductivity is the reciprocal of resistivity, i.e.,

$$\text{Conductivity} = \frac{1}{\text{Resistivity}}$$

The surface control panel of the induction equipment contains a reciprocator which converts conductivity to resistivity. Both values are printed on the log.

The induction log is well adapted for use in formations of low to moderate resistivity where normal fresh muds are used. Here it has the following outstanding advantages over the long normal and lateral curves of the electrical log:

1. It measures values close to true formation resistivity when the invaded zone resistivity is high (provided invasion is not extremely deep). To obtain a similar depth of investigation with the conventional electrical log, a long spacing would be required.

These measurements then would be considerably affected by surrounding formations.

2. It eliminates the shadow zones, reflection peaks, and reversals which sometimes confuse interpretation of the long normal and lateral curves. Hard streaks immediately above or below the zone of interest do not affect the measured value.

Induction-electrical log. The advantages of the induction log have led to its being combined with the short normal and SP to form the induction-electrical log. This combination log has proven so effective that it has replaced the electrical log to a large extent. At the present time more wells in the United States are surveyed with the induction-electrical log than are surveyed with the conventional electrical log. This is true in spite of the fact that the service was introduced only a few years ago and costs slightly more. The higher cost is necessary because the equipment is more expensive to build and maintain than that required for the conventional electrical log.

An actual comparison of a combination induction-electrical log and a conventional electrical survey is illustrated in Fig. 6. The formations are relatively consolidated. The large SP anomaly indicates that a fresh mud was used.

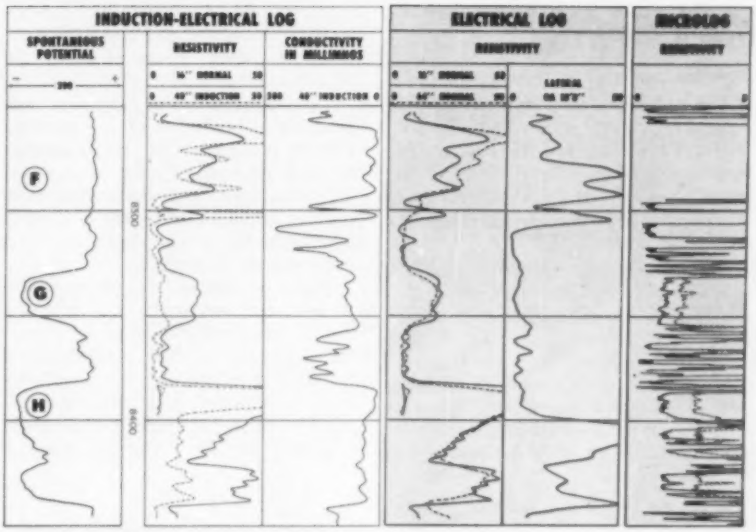
Several outstanding features of the induction-electrical log are well illustrated. Notice the sharp definition of the series of thin resistive beds near the top of the log. None of the curves on the electrical log, including the short normal, provide the detail that is apparent on the induction curve.

At the middle of the illustrated section we detect a deeply invaded water sand. Both the short and long normal curves are severely affected by the deep invasion. Only the lateral curve and the induction curve have sufficient depth of investigation to record values close to the true resistivity.

All of the lower sand section on the electrical log exhibits relatively high values of resistivity. The short and long normal curves read almost the same values throughout the zone. The lateral curve exhibits its characteristic lag at the top of the resistive bed.

From the electrical log it would be difficult, if not impossible, to distinguish between the gas productive section above 8400 ft and the water sand below. The induction curve, unhampered by distortions and with deeper investigation than the long normal, readily locates the gas-water contact. The upper ten feet of the sand produces 2.3 MMcf of gas per day with 46 bbl of distillate.

The laterolog. The laterolog, though a focused resistivity device, operates on an entirely different principle than the induction log. Electrical currents are sent from the device through the mud and into the formations. These currents are not permitted to concentrate in the low resistant column of mud as is the case with the electrical logging device (Fig. 7). Bucking voltages outside the measure electrodes cause the current to be beamed into the formation. This relatively thin disc of investigation causes the laterolog to sharply define even severe resistivity changes in the formations.



Consolidated formations.

FIG. 6

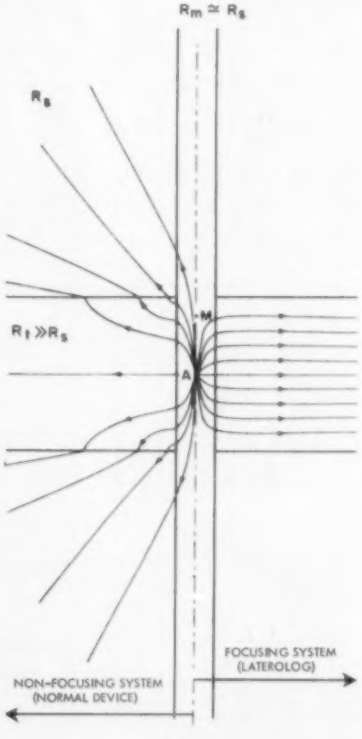


FIG. 7

The laterolog is particularly adapted to the logging of moderate to high resistivity beds that are drilled with salt mud. In such cases the formation resistivities of water bearing zones are accurately given by the laterolog. The resistivities of oil or gas productive zones are reduced somewhat by the invasion of the salty mud filtrate but correction may be applied to obtain the R_t of the zone.

In wells drilled with fresh mud the laterolog provides an extremely detailed record. However, since the invaded zone resistivity is considerably higher than the resistivity of a salt water bearing zone beyond invasion, the laterolog does not readily differentiate between oil and water productive sections. With shallow invasion the laterolog is not severely affected, but as the depth of invasion increases the laterolog reading rapidly approaches the resistivity of the invaded zone.

The electrical log, the induction log, and the laterolog are the devices used to determine the R_t of the formation. They all have one common feature. They must be recorded before casing is run into the well. The steel casing would act as a shunt and would prevent investigation of the formations.

Without a measurement of formation resistivity there is no means of calculating the water saturation of a formation. Therefore, a quantitative interpretation of a formation requires that not only must a resistivity log be

run but that it must be run before casing is set on a well.

Determination of Porosity

The resistivity of a formation will depend to a large extent upon its porosity. Therefore, before resistivity measurements may be interpreted in terms of water (or hydrocarbon) saturation, it is necessary to determine the formation porosity.

The devices used for the determination of porosity can be generally classified in two main groups. The first group consists of devices such as the microlog, which measures the resistivities of zones that have been flushed or invaded by the mud filtrate. The determination of porosity in this case is accomplished by use of the formation resistivity factor.

Since the formation factor of a clean water zone remains constant even after invasion, the flushed zone resistivity provides a means of calculating F.

$$F = \frac{R_o}{R_w} = \frac{R_{xo}}{R_{mf}}$$

Where R_{xo} = resistivity of the zone flushed with mud filtrate.

When the zone under study contains oil it is necessary to make corrections for the residual oil saturation (ROS) remaining in the flushed zone. If not corrected for, erroneous low values of porosity would be computed. Empirical corrections are employed.

The second group of porosity devices measure some property of the formation (other than resistivity) that is related to porosity. In this latter group we find the sonic log, the neutron log, and the gamma-gamma density log. Of this group, only the sonic log will be discussed in this article.

Porosity Determination Devices

Microdevices. Microdevices, such as the microlog and microlaterolog, provide a wealth of information for reservoir analysis and well completion. The instruments are designed to locate exactly the permeable beds, to give an accurate total pay thickness (sand count) in broken formations, and to provide additional data for the determination of other factors required in the modern logging program (Fig. 8). They accomplish this by measuring the resistivity of very small volumes of flushed formation close to the wall of the hole.

With the microlog, resistivity measurements are made with closely spaced electrodes mounted in an insulating pad which is pressed against the wall of the bore hole (Fig. 9). The system measures the average resistivity of a small volume of material which is directly opposite the pad and is, as a result, electrically insulated from the short circuiting action of the mud.

Two spacings are utilized. The two have different depths of investigation and the reading of the shorter spacing is more influenced by the presence of the mud cake. The curves therefore provide an excellent means of sharply differentiating between permeable and impermeable formations.

The microlaterolog is also run with an insulating pad device. However, the microlaterolog differs from the microlog in that the current is focused into the formation and only one resistivity curve is recorded. The focusing is accomplished in approximately the same manner as employed with the laterolog.

The microlaterolog is used primarily in salt muds, since the microlog is handicapped by a severe contrast between formation and mud resistivities.

A caliper curve is recorded with both types of microdevice logs. The recording gives the distance (hole diameter) between the faces of the insulated pad and a back-up pad on the opposite side of the device. The continuous recording of the hole diameter is valuable for the location of caved zones and for the detection of mud cake. It is also used to compute the hole volume (for cement requirements), for determining packer seats, and for positioning casing centralizers.

Sonic log. The sonic log is a continuous recording of the length of time required for a sound pulse to travel

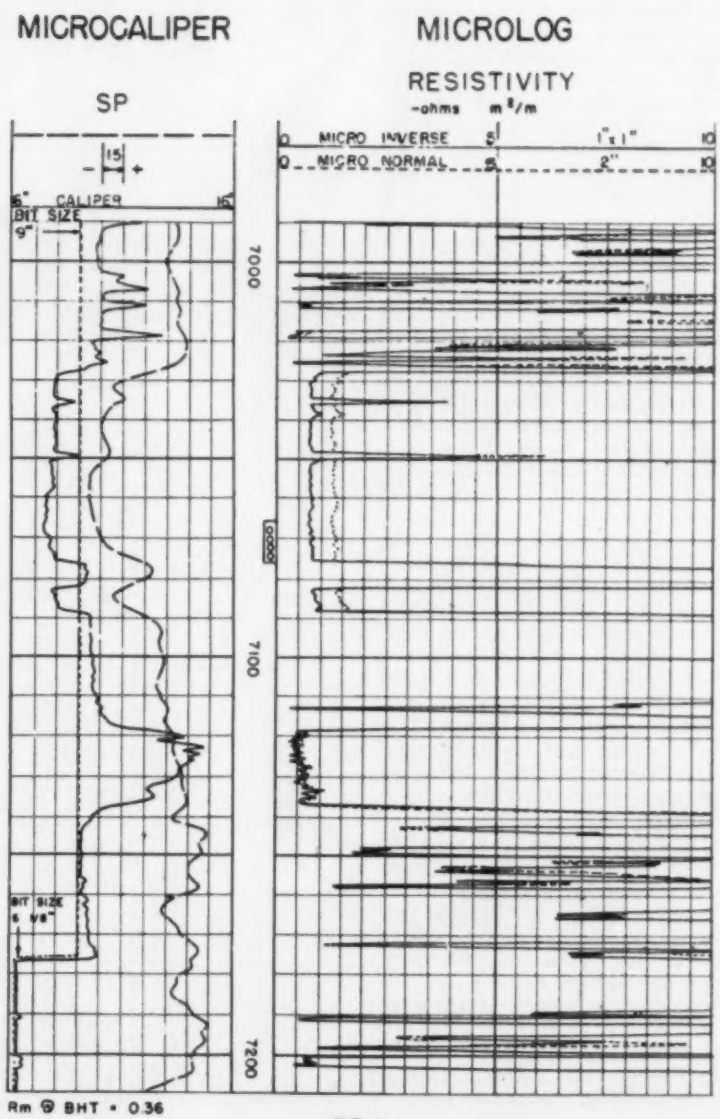


FIG. 8

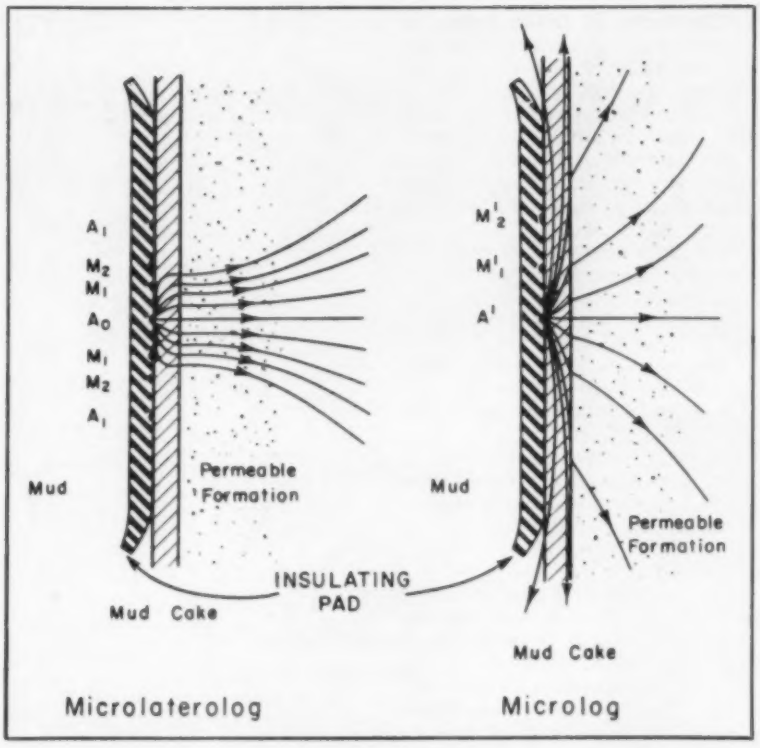


FIG. 9

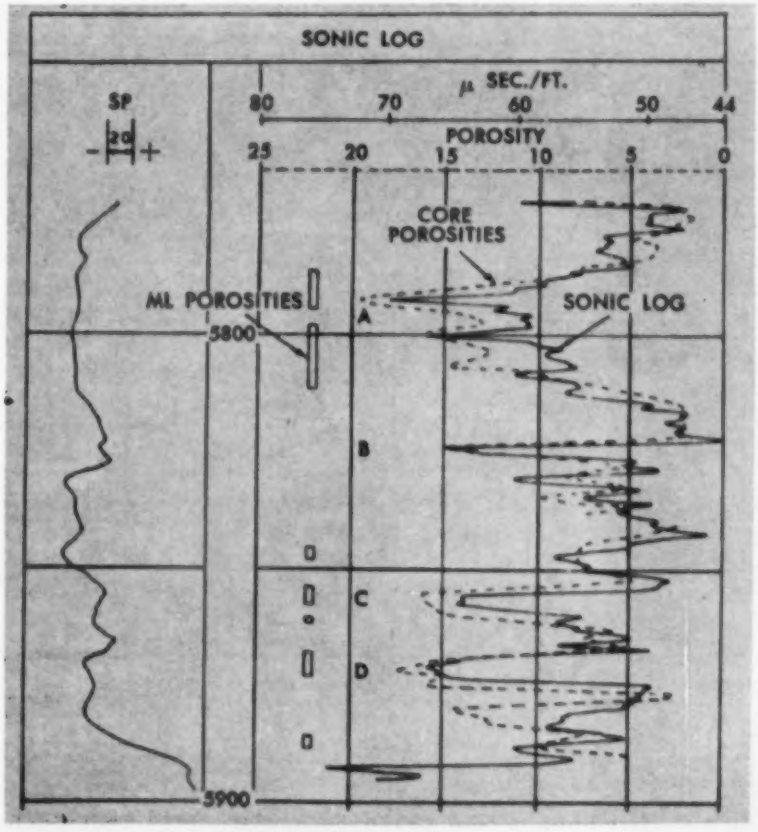


FIG. 10

through one foot of formation in a path parallel to the borehole. The velocity with which a formation will transmit such a pulse is, to a large extent, dependent upon formation porosity (Fig. 10). The higher the porosity of a formation, the lower the velocity. It can be seen then that the time required for sound to travel through a high porosity formation will be greater than for a low porosity formation.

The presence of hydrocarbons in the path of the sound pulse will cause an even lower velocity. In low porosity formations invasion is normally deep and only mud filtrate is present within the pore space being investigated. However, in higher porosity formations, invasion is usually shallow and two fluids are present in the pore space being investigated. This phenomenon frequently causes the presence of hydrocarbons to be readily discerned (Fig. 11). When the sonic log reading is compared with formation resistivity measurements, the presence of hydrocarbons can often be qualitatively determined.

The sonic log has, in only a little over a year, become a major tool for electrical log interpretation. Formation velocity measurements have been utilized for years in the interpretation of seismic data but it has only been during the past two years that these measurements have been applied to log interpretation.

A porosity determination based upon the measurement of some parameter other than resistivity is particularly helpful to log interpretation. In many instances difficult interpretations can best be solved through the use of several different methods of porosity determination. In this way factors that complicate one method may be obviated by a second method.

Logging Programs

The foregoing discussions of fundamentals of log interpretation and logging methods indicate that no single logging method will afford a complete reservoir interpretation. It is necessary that a combination of logs be used.

The proper choice of logging services should be based upon well conditions. Both the type of formations and the type of drilling fluid will influence the choice of logging program to be used.

Classification of formations. Formations are generally classified as hard, medium, and soft. This terminology corresponds to that of drillers and is more properly related to porosity.

Hard formations are those in which the reservoir rocks are carbonates or sandstones with less than 15 percent porosity. They are characterized by rel-

atively high resistivity and are frequently interbedded with dense impermeable zones. The true resistivity of these beds can, in most cases, only be determined through the use of focused resistivity devices. In such formations, porosity is most accurately obtained with the sonic log. The neutron log, though less precise, is sometimes used.

Medium formations are those in which reservoir beds exhibit porosities between 15 and 25 percent. In this range the proper choice of logging program will be determined by the type of drilling mud.

Soft formations are unconsolidated sections that are predominatly shales and high porosity sands. The porosities will range upward from 25 percent. Such conditions are most commonly encountered along the Gulf Coast and in California. The sands are often very shaly.

Invasion by mud filtrate in soft formations is normally very shallow. Therefore, accurate determination of true formation resistivity is less difficult than in the case of the more deeply invaded hard formations. Even so, the induction-electrical log is more efficient than the nonfocused electrical log since bed thickness effects are minimized.

Porosity determinations may be accomplished by a variety of methods. The sonic log provides an excellent means of determining porosity even though corrections may be required for lack of compaction and for the presence of shale or hydrocarbons in the sand.

The microlog can be used for porosity computations if invasion is adequate.

Classification of drilling fluids. For logging purposes, drilling fluids are generally classified as fresh mud, salt mud, oil-base mud, and gas or air.

Fresh muds are water base muds that contain relatively few dissolved salts. Normally muds are considered fresh when they are at least five times more resistive than the formation waters ($R_{mf} > 5R_w$).

Salt muds are water-base muds that contain a high percentage of dissolved salts. In such muds the mud filtrate has approximately the same resistivity as the formation waters.

Oil-base muds, as the name implies, have oil for their base, or their continuous phase, and do not conduct electrical current.

Air or gas drilled wells contain no fluid. It is necessary to use logging devices that do not require a fluid to establish contact with the formation.

Conclusion

This discussion of electric logging of wells has primarily dealt with the qualitative methods of interpretation. For such uses of the logs it is only necessary to understand the basic principles upon which the various logging devices operate and to be aware of the nature of the tool response to formation characteristics. A proper logging program will, in most cases, provide a simple and rapid means for locating oil or gas bearing zones. However, the evaluation of formation porosity and water saturation requires the use of quantitative methods of interpretation.

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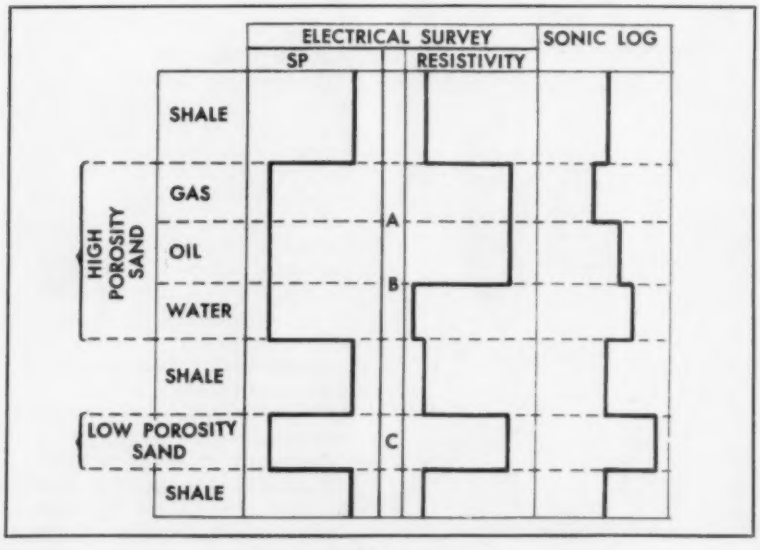

FIG. 11

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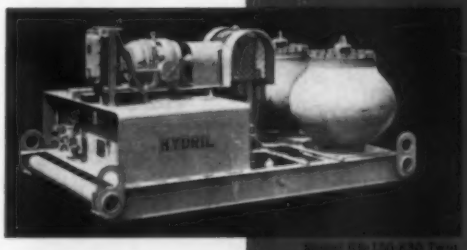

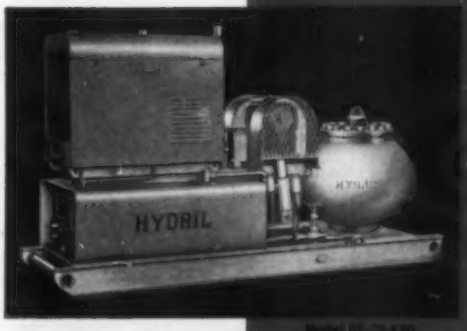

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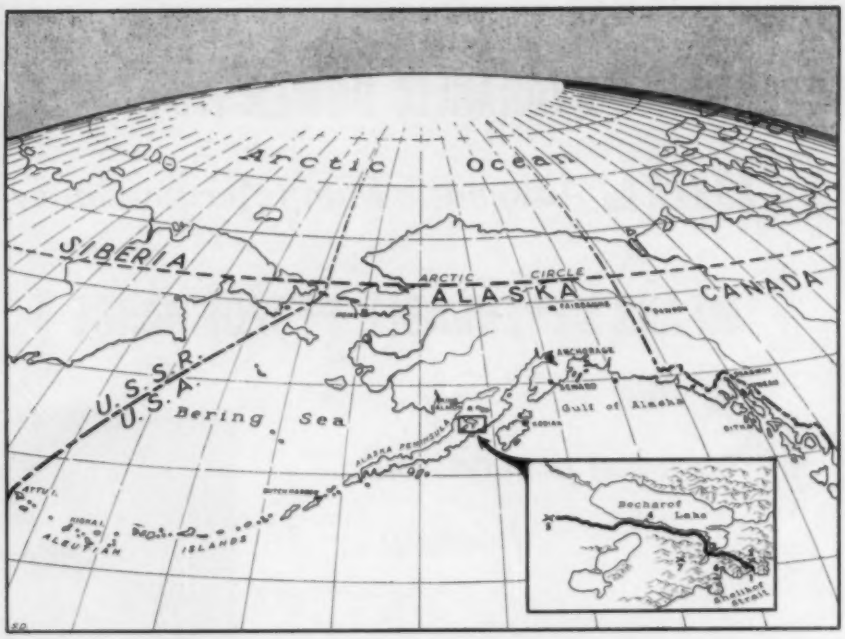


Location is pinpointed on this map which shows General Petroleum's Lake Becharof project on the Alaska Peninsula. The numbered inset is an enlargement of the actual area where the well is being drilled: (1) Jute Bay, where supplies were unloaded; (2) Bear Creek, the first headquarters and where another oil company drilled unsuccessfully; (3) crossing of Lake Becharof; (4) Gas Rocks, prominent terrain feature on Lake Becharof; (5) General Petroleum's well location; (6) Kanatak, deserted Aleut Indian village; (7) site of old oil camp where General Petroleum, in conjunction with two other companies, drilled unsuccessfully from 1923 to 1926. The heavy black line is the tortuous road, approximately 65 miles long, over which the equipment was carried.

Men, Machines . . . and Mud

Moving In—Alaska-Style

Here's the picture story of the hardships that General Petroleum met . . . and overcame . . . while moving in to drill a wildcat in Alaska's forbidding Lake Becharof region

ONE OF THE MOST DRAMATIC EXAMPLES of the never-ending search for oil is underway in the desolate, bleak Lake Becharof region of the Alaska Peninsula where General Petroleum Corporation has started drilling a wildcat oil well.

Drilling a well in an easily accessible location never is a simple job, but probably the most difficult, heart-breaking, challenging part of this Alaska project took place before drilling could begin.

The site for the wildcat had been chosen after extensive geological and geophysical exploration. The conditions for the discovery of oil were considered favorable, but the only sure way to find out was to drill. That's the problem. The well site is about 3100 air miles from Los Angeles, more than 300 miles from Anchorage and 65 miles from Bear Creek, where another oil company (Humble) had drilled unsuccessfully for oil previously. General Petroleum contracted with that company to use its rig and camp facilities.

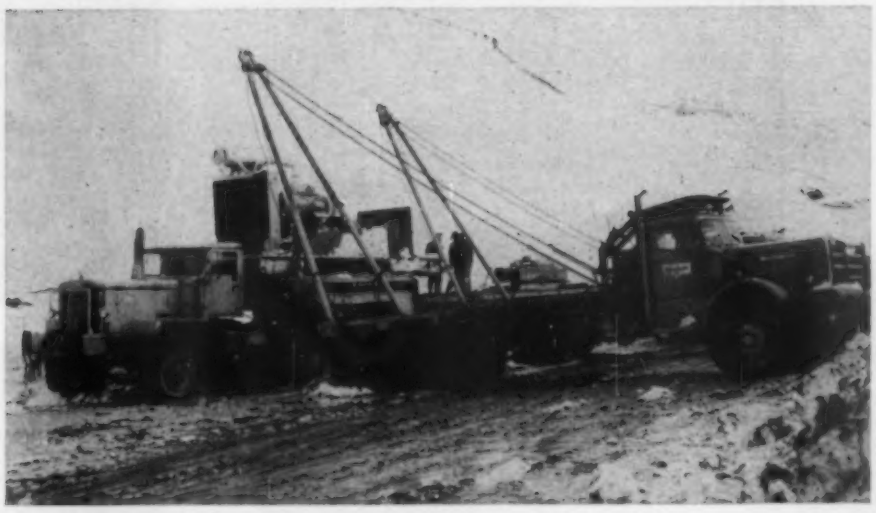
So far so good. But this is Alaska, not California's San Joaquin Valley. The connecting link between the equipment and the well site was non-existent. This was where man's ingenuity and tenacity entered the picture.

General Petroleum Freeway

Much of the equipment was stored at Jute Bay, a part of Shelikof Strait in the Gulf of Alaska. Two big barges loaded with lumber, fuel oil, trucks, drill pipe and other supplies were dispatched from southern California. This movement was intended to synchronize with the construction of a road, laughingly called the General Petroleum Freeway, over which the heavy equipment was to be transported.

But Mother Nature had other ideas. When conditions were right for road building — tundra frozen so solid that it would hold more than 100 tons of truck and equipment, little wind or snow, stream beds iced over — then the storms delayed the barges. Once the little convoy had to hide out at a sheltered part of Montague Island, off the south side of the Kenai Peninsula until a storm had subsided. Storms greeted the barges on arrival at Jute Bay, and only a part of the equipment could be unloaded before refuge had to be sought at Kodiak Island.

While this was taking place on the water, what the road builders had feared most — the spring thaw — was doubling their back-breaking efforts on land. The tundra refused to



Power unit for the rig is loaded onto a 60-ton truck near Bear Creek prior to departure for the new well site, 65 miles away.

cooperate and gave way, sometimes leaving holes several feet deep.

The road was nothing more than a thread which worked its way through mountain passes, over streams, across lakes and through the tundra — a thread frayed almost every foot of the 65 miles by snow, oozing muck that seemed to suck the heavy trucks into it, water — icy and treacherous.

Men and machinery combined to build this all-important link, foot by foot. Caterpillars pushed ahead while men like Ted Mathews of Fairbanks, who had been building roads in Alaska since 1930 and who called this "the toughest job by far I've ever had," walked, carefully selecting the most solid ground.

Finally enough of the road was completed so that some of the equipment could start the move.

Mother Nature still was unhappy. At places culverts were washed out, causing time consuming reconstruction. The wind tormented the men; snow fell, but never vertically. The wind caught it and drove it into the men's faces.

Eight Miles a Day

One convoy of three 60 to 70 ton trucks carrying part of the rig and other heavy equipment started out from Bear Creek shortly after the 4 o'clock dawn. Two caterpillars, working like giant ants, escorted the trucks, pushing, pulling and lifting. John Clark, another Alaskan, was the "wagon master." He walked or rode on fenders all of the way, always looking out for treacherous holes, signaling for the "cats" to move in and pull or push. The wind whipped his face, the snow chilled him through, but he delivered the load — 65 miles in 8 days.

If he hadn't been devoted to his job, it would have taken many more days because the trucks rarely moved faster than 1 mile an hour. His drivers wanted to get the job done, too. The usual quitting time was between 8 and 9 p.m. First call was 3 a.m., chow at 3:30 and then they were off again. A portable house was carried on one of the trucks, and all of the sleeping and cooking was done inside.

The site itself was checked by General Petroleum men. Robert D. Townsend Jr., project engineer; Gilbert Frick, drilling foreman; Lionel Hammerson, mud man; and Richard Hulbert, equipment man, all inspected the location and planted a flag — the actual location. Earl Walker, tool pusher for Rowan Drilling Company of Fort Worth, which has the drilling contract, worked with the General Petroleum men constantly.

These are men, real men, devoted, loyal, rugged, everyone with a single hope — oil. Now the main job, drilling for oil, has begun, but it never could have started without men and equipment winning the titanic battle against a stubborn Mother Nature.

The Men Who Did It

Men like Red Adams of Rowan show the devotion to duty demonstrated by everyone connected with the job. During the unloading, he noticed that a valve on a barge had to be opened to connect with the fuel line to shore. Without hesitation he stripped off his clothes and jumped into the 34-deg water, did his job hurriedly and was ready to resume his tasks, but his co-workers made him warm up first.

Bob Townsend of General Petroleum spent 18 hours a day seeing that the equipment was unloaded, the well site located correctly, getting barges and trucks. Gil Frick had to check and double-check equipment and personnel and tend to all of the time-consuming tasks connected with the job. Lionel Hammerson and Dick Hulbert serviced engines and worked many hours waiting for the drilling to begin.

Helicopters are used for transportation of personnel and supplies from King Salmon to Bear Creek and the site. The pilots are experts who check the weight of their loads carefully. Sometimes they are grounded because of heavy winds.

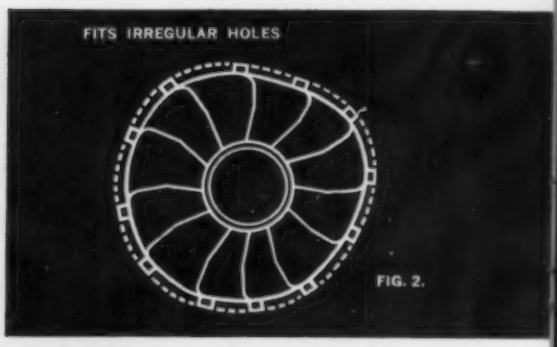
The Rowan employees have three huskies who follow the men everywhere, but at times they become vagabonds. One day Walker was on an inspection trip by helicopter and thought he had spotted three wolves from the air about 15 miles from camp. He had the pilot swoop the plane closer to ground for a closer view and realized the huskies had run from camp for a romp in the snow. They returned that night.

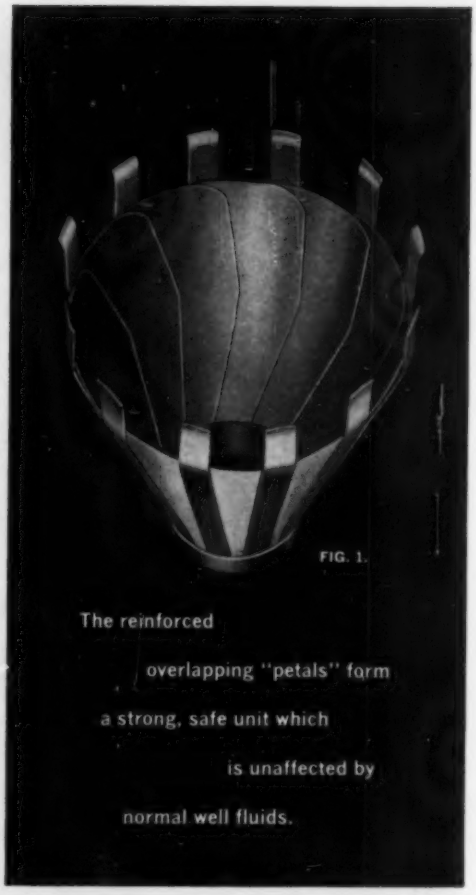
Not all of the animals turn out to be dogs. There are moose and caribou in the area. Bears are beginning to come out of hibernation. The men usually take sidearms into the wilds for protection. One firm rule: "Never let an animal get between you and your transportation." There are thousands of birds, ducks, swan, geese and others.

About 20 miles or so from Bear Creek is an old oil camp, which General Petroleum had a part interest in back in 1923. The well was drilled unsuccessfully until 1926. The walking beam still stands, and many pieces of drilling equipment were left behind. Oil-soaked tundra, used for heating purposes, was stacked in one of the roofless sheds. Most of the buildings are still standing, but snow and wind have bowed the roofs.

The wind at Bear Creek has been known to reach a velocity of 155 miles an hour and the temperature 23 degrees below. ★ ★ ★

keep cement where you want it!





For Problem Cementing, where a lower permeable (or weak) zone must be protected from the cement slurry, or from sloughings and cavings, the Baker METAL PETAL Basket is safe and successful.

A number of "petals" made of flexible sheet steel are mounted on reinforcing spring-steel ribs which in turn are mounted on a ring to form the Basket. This all-metal construction provides unusual strength; there is little likelihood of damage to the unit while running in the well.

Safe, Automatic Operation—While running in the well, upward pressure of the fluid (see Fig. 5) tends to close the petals, thus providing fluid passageway between the Basket and the wall of the hole, without distortion or damage to the Basket. As soon as the casing comes to rest, upward pressure by the fluid is relieved and the petals expand to contact the wall of the hole (see Fig. 6). Any tendency of fluid to move downward then presses the flexible petals more firmly against the entire circumference of the hole. Solids which are strained from the fluid serve to build a bridge inside the Basket, which is thus converted into a one-way annular packer of great strength and effectiveness (see Fig. 7).

Fits Large or Irregular Holes—The "Metal Petals" not only expand to contact the entire circumference of large-diameter holes (see Fig. 4) but also pack-off in holes of irregular shape as shown in Fig. 2. The independent action of the individually mounted overlapping petals permits successful use of Baker Metal Petal Baskets in casing programs with minimum clearances (see Fig. 3).

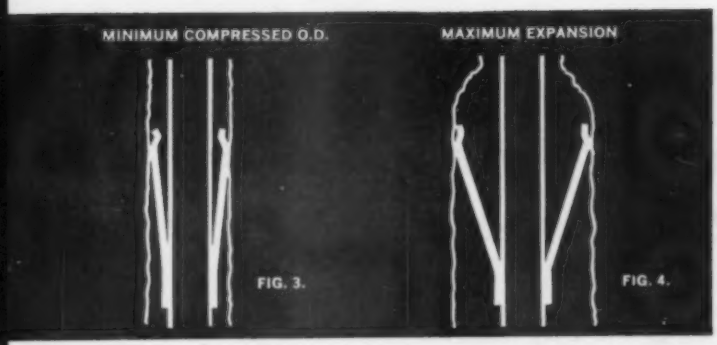
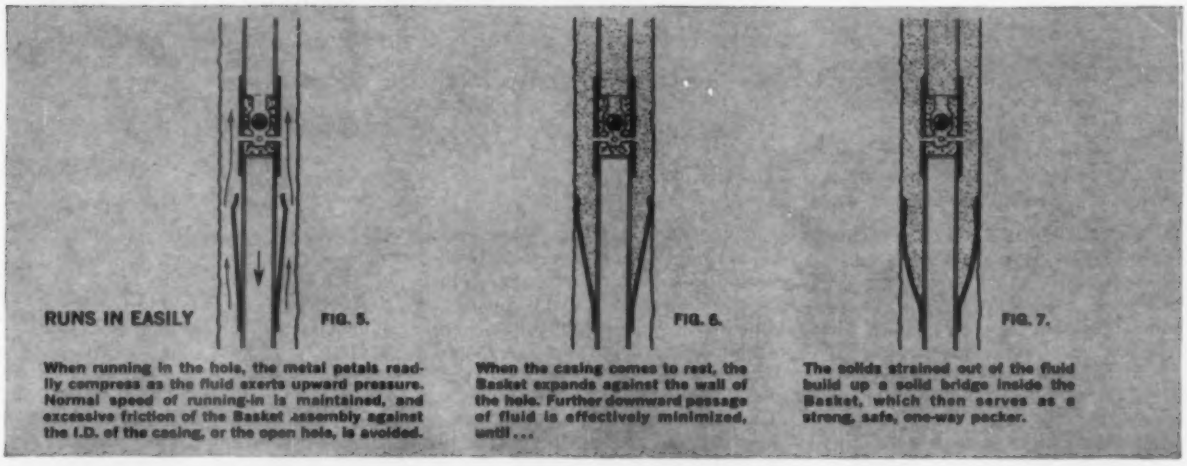


FIG. 2.
FITS IRREGULAR HOLES – The Basket expands to contact the entire circumference of irregularly shaped holes.

FIG. 3.
MINIMUM COMPRESSED O.D. – Less than ½" greater than coupling O.D. – providing ample running-in clearance.

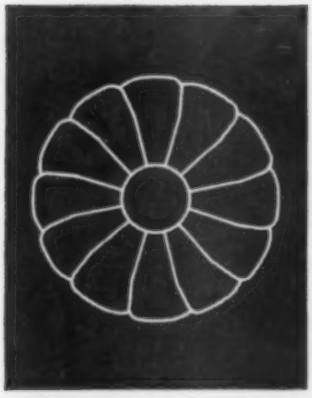
FIG. 4.
MAXIMUM EXPANSION – The Basket expands to more than twice the diameter of the casing on which it is run in sizes 5½" and larger.



When running in the hole, the metal petals readily compress as the fluid exerts upward pressure. Normal speed of running-in is maintained, and excessive friction of the Basket assembly against the I.D. of the casing, or the open hole, is avoided.

When the casing comes to rest, the Basket expands against the wall of the hole. Further downward passage of fluid is effectively minimized, until ...

The solids strained out of the fluid build up a solid bridge inside the Basket, which then serves as a strong, safe, one-way packer.



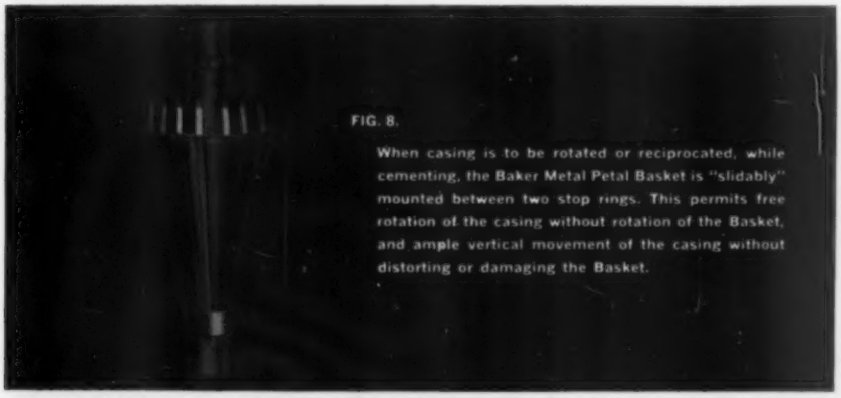


FIG. 8.

When casing is to be rotated or reciprocated, while cementing, the Baker Metal Petal Basket is "slidably" mounted between two stop rings. This permits free rotation of the casing without rotation of the Basket, and ample vertical movement of the casing without distorting or damaging the Basket.

Mountings Meet All Needs—The Baker Metal Petal Basket is furnished as a separate unit for installation to meet any requirement. Generally it is *slidably* mounted by spacing two split stop rings some distance apart to allow free travel of the Basket and free rotation of the casing. Baskets can be furnished affixed to either a *plain* or a *perforated* nipple to meet cementing requirements.

Baker Metal Petal Baskets are used extensively in combination with Baker Stage Collars to retain and support the cement slurry for the second stage. Baker Casing Centralizers are normally used above and below such combinations to provide uniform annular clearance.

Any Baker representative will give specific recommendations for the use of Baker Metal Petal Baskets; or see the BAKER (or Composite) Catalog.

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An analysis of . . .

Clay Mineralogy Problems In Oil Recovery

Part 1: The importance of the clay mineral content of petroleum reservoir sands has received increasing attention in recent years. This report presents a survey of the present knowledge of the subject as it affects oil recovery

John E. Moore, *University of Illinois, Urbana, Illinois*

IN WATERFLOODING or pressure maintenance operations, fluid is introduced to flush the residual oil from the sandstone reservoir. All fluids are not compatible with reservoir clays. If the reservoir clays are water-sensitive, as are montmorillonite, degraded illite, degraded chlorite, or some mixed-layer clays, they may react with a flooding fluid differing in ionic content and concentration from the brine present in the producing formation. Natural clays present in reservoir sands are usually flocculated and unexpanded. The reaction of water-sensitive clays to fluids of lower salinity and/or different ionic content than the formation fluid will cause expansion and deflocculation of the clay minerals. This results in a decrease in the permeability of the reservoir sand to flooding fluid, due to plugging of the pore spaces.

Most reservoir sandstones contain some clay minerals. A content of only 1 to 4 percent of water-sensitive clays in a fine-grained sandstone may completely plug the formation if the injection fluid is not compatible with these clays. Injection fluid used in such operations should have approximately the same concentration and composition as the original formation brine. The use of fresh water should be avoided if water-sensitive clays are present in the reservoir sand.

An investigation of the relation of clay minerals to reservoir performance should include study by several complementary laboratory techniques to obtain enough data for an adequate evaluation of the clay minerals and their properties.

CHARACTERISTICS OF CLAY MINERALS

Recent research has shown that clay materials are composed of extremely small crystalline particles. These crystalline particles have been classified according to their crystal structure into a few groups known as clay minerals.[1] Most individual clay mineral units are predominantly flake or platy shaped particles and usually occur in the 2-micron or smaller size range. The clay minerals are essentially layered hydrous aluminum silicates which may contain small amounts of alkalies and alkaline earths and have some substitution of aluminum by magnesium and iron.[2]

Clay minerals consist of relatively simple building units. The two fundamental building blocks are the silica tetrahedral sheet and the alumina octahedral sheet, as shown in Fig. 1. These units extend indefinitely in two directions and have a definite thickness ranging from 7 to 17 angstrom units (one angstrom unit = one 10 millionth of a millimeter). The silica tetrahedral sheet is composed of a silicon atom surrounded by four oxygen or hydroxyl atoms and, in the clay mineral lattice, is arranged in layers with the flats on one side and the points of the tetrahedrons on the other. The alumina octahedral sheet is composed of an aluminum atom surrounded by six hydroxyl atoms. The octahedral sheet may also contain iron or magnesium.

The present gibbsite structure, $Al_2(OH)_6$, is formed when aluminum is present. This structure is unbalanced because only two-thirds of the possible positions in the lattice are filled. The brucite octahedron structure, $Mg_3(OH)_6$, is formed if magnesium is present and this structure is in a balanced form, since all positions in the lattice are

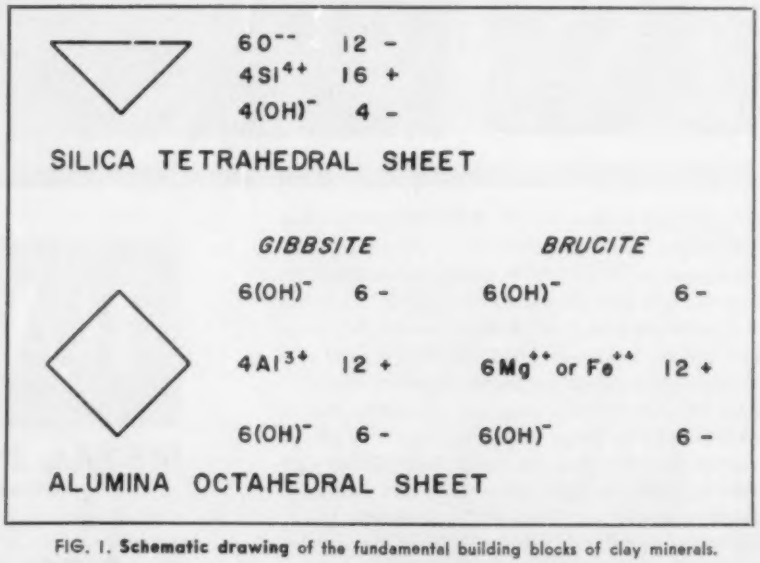

FIG. 1. **Schematic drawing** of the fundamental building blocks of clay minerals.

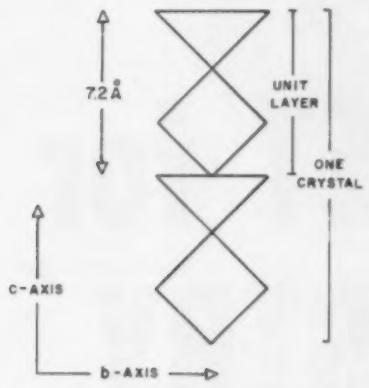

FIG. 2. **Schematic drawing** of the crystal structure of kaolinite.

filled.[2] A schematic drawing showing how these fundamental building blocks are built up by the bonding together of tetrahedral and octahedral (brucite and gibbsite) sheets to form the clay mineral groups is reproduced in Fig. 2, 3, and 4.

The most important clay minerals of interest to the petroleum geologist and engineer are the kaolinite, montmorillonite, illite and mixed-lattice minerals.

Structure of Clay Mineral Groups

Kaolinite group. Kaolinite, the principal member of this group, is composed of one silica tetrahedral sheet and one alumina octahedral sheet (gibbsite) which are combined in a unit, as shown in Fig. 2. This structure is sometimes called the 1:1 lattice type. The unit layer of kaolinite is 7.2 angstroms thick in the c-axis direction. Charge distribution within the tetrahedral and octahedral sheets is balanced and there is very little substitution of ions within the lattice.

The basic kaolinite units are bonded tightly together in the c-axis direction by hydrogen bonding which prevents expansion of the lattice structure by excluding water penetration into the lattice.[1] There is a high degree of regularity in the stacking of well-crystallized kaolinite units. Kaolinite crystals range in size from 0.3 to 4 microns in flat surface dimension and from 0.05 to 2 microns in thickness.[2] The theoretical kaolinite formula is $(OH)_8Al_4Si_4O_{10}$.

Montmorillonite group. The montmorillonite structure is composed of two silica tetrahedral sheets with a central alumina octahedral sheet (gibbsite or brucite) between them and all tips of the tetrahedrons point toward the center octahedral sheet, as shown in Fig. 3. This group is referred to as the 2:1 lattice type. Charge distribution within the lattice, unlike kaolinite, is unbalanced, due to substitutions within the octahedral sheet of Fe^{++}, Fe^{+++}, and/or Mg^{++} for Al^{+++} and a limited substitution (less than 15 percent) by Al^{+++} for Si^{++++} in the tetrahedral sheet.[2] These substitutions leave a +1 charge deficiency per 1.5 unit cells and the excess charges are partially neutralized by the absorption of ions (Ca^{++}, Mg^{++}, H^+, and Na^+) on the outside surface and between unit layers of the mineral. Stacking of silica tetrahedral-alumina octahedral-silica tetrahedral units results in a very weak chemical bond and good cleavage between successive units, because oxygen layers are adjacent to oxygen layers.

The outstanding feature of the montmorillonite structure is that water and other polar-organic molecules can enter between the unit layers and cause expansion of the lattice in the c-axis dimension.[2] Lattice expansion of montmorillonite, and thus the unit cell thickness, varies from 9.6 to 17.1 angstroms (or greater). This variation of the c-axis dimension is caused by the entry of water into the structure and the amount of water allowed to enter is controlled by the structure and nature of the exchangeable cation. Montmorillonite crystals occur as extremely small particles, due to the fact that some minerals of this group break down to flake-shaped units that approach the unit cell thickness. The theoretical formula for montmorillonite is $(OH)_4(Al_4 \cdot Fe_4 \cdot Mg_4)Si_8O_{20} \cdot nH_2O$.[3]

Illite group. The illite structure (hydrous micas or mica-like minerals) is composed of two silica tetrahedral sheets with a central alumina octahedral sheet (gibbsite or brucite) and is therefore similar to the structure of montmorillonite. This group is also referred to as a 2:1 lattice type (illustrated in Fig. 3). Illite clay minerals differ from montmorillonite clays in that there is a greater replacement of Al^{+++} for Si^{++++} in the tetrahedral sheet. The structure is also unbalanced due to substitution of Fe^{++}, Fe^{+++}, and Mg^{++} for aluminum in the octahedral layer. Substitutions in the octahedral and tetrahedral layers result in a +1 charge deficiency per unit cell, which is greater

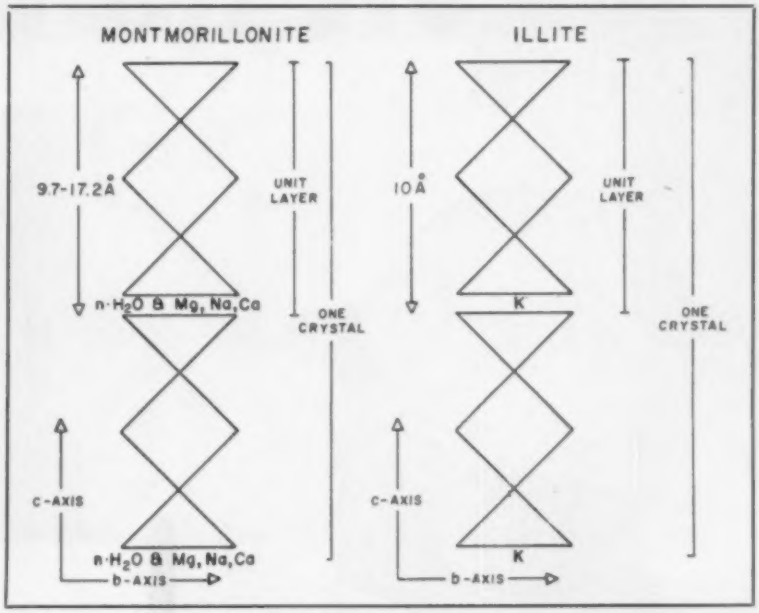

FIG. 3. **Schematic drawing** of the crystal structure of montmorillonite and illite.

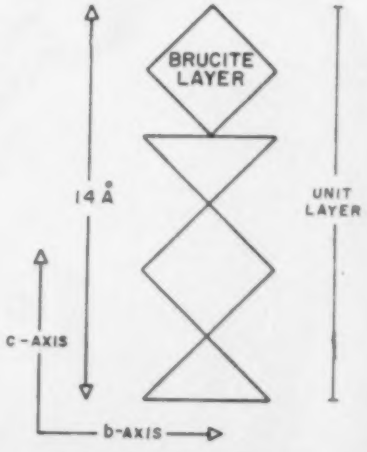

FIG. 4. **Schematic drawing** of the crystal structure of chlorite.

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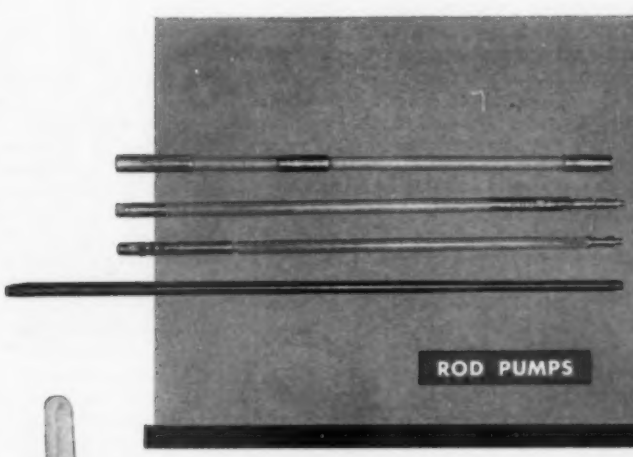

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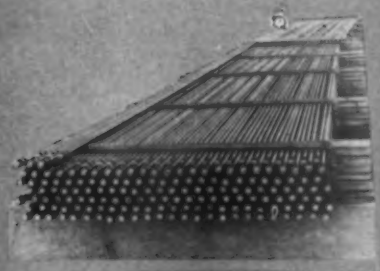

SUCKER RODS

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than the charge deficiency in montmorillonite, and this charge deficiency is balanced frequently by K^+ ions.[2] It should also be noted that the major part of the unbalancing of the crystal lattice of illite results from substitutions within the tetrahedral layer, while in montmorillonite the unbalancing occurs in the octahedral layer.

Potassium ions (K^+), when present in the structure, occur between the tetrahedral layers of two successive units where they fit exactly into perforations in the surface oxygen layers and are held tightly due to the unbalance of the structure in the tetrahedral sheet.[2] Potassium ions form such an excellent bond between illite units that they do not expand in the presence of water.[1] However, the potassium ion is very susceptible to leaching action of slightly acidic water and, therefore, in some illite clays the potassium may have been removed from the structure and replaced by another cation. These minerals, called degraded illites when potassium is removed, allow entry of water between unit layers, causing expansion.[4] Degraded illites in which almost all potassium is removed will expand to 14 or more angstrom units, depending on the type of exchangeable cation present. Mixed-layer complexes of illite and montmorillonite are known to occur and their swelling may be due only to a small amount of montmorillonite.

Thickness of the illite unit cell is 10 angstroms and the average size of the individual particles is small, about 1 to 2 microns.[2] The theoretical formula for the illite group is $(OH)_4\ K_y(Al_4 \cdot Fe_4 \cdot Mg_4)(Si_{8-y} \cdot Al_y)O_{20}$.[3]

Mixed-layer minerals. Mixed-layer or mixed-lattice clay minerals are composed of more than one clay mineral.[2] This group of clay minerals may be divided into two different types — regular mixed-layer structures and random mixed-layer structures.

The chlorite group of clay minerals is an example of regular mixed-layer structure because there is a regular repetition of different layer structures in the c-axis direction.[2] The chlorite structure is composed of two silica tetrahedral sheets with a central octahedral sheet (usually brucite) and a brucite layer between the mica sheets, as shown in Fig. 4. The chlorite group is a mica-type (illite) clay mineral. However, it differs from illite in having a brucite layer in place of the potassium between the illite layers.

Charge distribution within the lattice is unbalanced, due to substitution within the octahedral and tetrahedral layers. The brucite layer is an octahedral type sheet, consisting of either Al^{+++}, Mg^{++}, or Fe^{++} ions surrounded by six hydroxyl atoms. The chlorite group contains various different members, due to the kind and amount of substitutions within the brucite layers and to the octahedral and tetrahedral positions of the illite-like layer.[2] The unit cell is 14 angstroms thick and the units have a complex stacking arrangement in the c-axis direction.

Well-crystallized forms of chlorite do not expand in the presence of water, but, however, degraded forms may do so. Degraded chlorite is formed by first altering the brucite layer by changing the Mg, Fe, Al, (OH) to Mg-Fe-Al + H_2O, which forms the clay mineral vermiculite, and then by removing the Mg, Fe, Al from the brucite layer. It would seem from the structure of chlorite that it should have about the same physical properties as illite.[5]

Random mixed-layer clay minerals are formed by the random, irregular interstratification of layers in which there is no uniform repetition.[2] Minerals of this type appear to be very common. Some examples are: Montmorillonite interlaminated with illite, chlorite interlaminated with vermiculite or degraded chlorite, and degraded illite interlaminated with well-crystallized illite. The degree of interlamination of these minerals may be on an exceedingly minute scale.

In such minerals a small amount of expandable clay may cause planes of weakness to develop, due to the entry of water into the expandable clay unit.[3] Laboratory determination of this type of clay mineral is very difficult and in many cases the random mixed-layer minerals have been overlooked.

Clay-Mineral Properties

Variation in properties of the specific clay mineral groups depends primarily on structure and composition. Therefore, each group has its own distinctive set of properties.[1] The properties of clay minerals considered here are those of major importance to a consideration of the causes of clay mineral behavior in the petroleum reservoir. These intimately related properties are: Base exchange, clay-water characteristics, flocculation-deflocculation, and adsorption of organic compounds.

Base exchange may be described as exchange of ions in solution for those in a solid. The commonest exchange ions in clay minerals are the cations Ca^{++}, Mg^{++}, H^+, K^+, NH_4^+, and Na^+.[2] The exchangeable cations are held between the clay mineral plates, as well as around the outside of the structural units. It is important to note that, in the base-exchange process, the structure of the clay mineral is not altered.

Cation exchange is influenced by the electrical charge of the clay particle. This electrical charge is controlled by substitution in the tetrahedral or octahedral parts of the lattice, broken bonds within the structure, and by hydrogen of exposed hydroxyls. Lattice substitution is a major cause of cation exchange in montmorillonite and vermiculite, and is an important cause of exchange in illite and chlorite. Broken bonds are a major cause of cation exchange in kaolinite and an important factor in exchange of illite and chlorite. Hydrogen of exposed hydroxyls is an important cause of cation exchange in kaolinite.[2]

The cation or base-exchange capacity of a clay mineral is a measure of the ability of a clay to carry exchangeable cations. This ability is expressed in terms of milliequivalents per 100 g of clay determined at a pH of 7 (neutrality). The order of cation-exchange capacities for the different clay mineral groups is: Montmorillonite (80 to 150 me per 100 g) $>$ chlorite and illite (10 to 40 me per 100 g) $>$ kaolinite (3 to 15 me per 100 g).[2] Clay mineral groups vary in base-exchange capacity due to differences in degree of crystallinity (also degradation) and particle size. In general, the base-exchange capacity increases with a decrease in crystallinity and particle size.

Grim[2] has shown that the order of replaceability of cations will vary according to the following factors: Effect of concentration, population of exchange positions, nature of anion, nature of cation, and nature of the clay mineral.

The relative replacing power of one cation by another is shown in the following series: $Li^+ < Na^+ < K^+ < Mg^+ < Ca^+ < H^+$.[1] Therefore, at equal concentrations, Ca^{++} will displace a greater fraction of Na^+ than Na^+ will replace Ca^{++} and Ca^{++} will be more difficult to replace. In certain positions within the crystal lattice, however, the cations Mg^{++} and K^+ are difficult to exchange completely.

The general effect of increased concentration of the replacing cations will result in a greater exchange action by that cation. By population of exchange positions is meant the degree to which the replaced ion saturates the exchange spots on the clay mineral. Their ease of release will depend on the type of cation and the saturation of the clay by that cation. For example, as the percent of exchangeable Ca^+ on a clay surface becomes smaller, the more difficult is its removal. On the other hand, Na^+ shows the reverse relationship.

The nature of the anion in combination with the replacing cation will cause considerable variation in replaceability. Both the replacing power and the firmness with which the exchange cation is held in the structure are increased by a higher valence of the ion, or, in

ION	RADIUS
O^{--}	1.3 Å
OH^{-}	1.3 Å
K^{+}	1.3 Å
Ca^{++}	1.06 Å
Na^{+}	0.98 Å
Fe^{++}	0.83 Å
Fe^{+++}	0.67 Å
Mg^{++}	0.78 Å
Al^{+++}	0.57 Å
Si^{++++}	0.39 Å

FIG. 5. **Relative size of ions** associated with clay minerals (modified after Morris, et al.[6]).

other words, divalent ions have higher replacing power than monovalent ions. The H^{+} ion is an exception to the rule, for it generally behaves like a divalent ion.

An increase in the ionic size of cations of the same valence will increase their replacing power. A comparison of the radii of some ions associated with clay minerals is reproduced in Fig. 5. K^{+}, which has a radius of 1.33 angstroms, fits closely into the cavities formed by the hexagonal net of oxygen on the clay surface (radius, 1.4 angstroms), however, the ion is very tightly held on the clay surface and is, therefore, very difficult to replace.[1] Furthermore, studies have shown that the cation replaceability series is not completely valid for all clay mineral groups, but that there exists a separate series for the various clay minerals.[2]

The rate of cation exchange has been found to vary with the concentration of cations, type of clay mineral, and nature of the anion.[2] Investigations of soils and their reaction with ionic solutions have shown that the rate of cation exchange is quite rapid and takes place immediately upon contact of the soil with the solution.[6]

The base-exchange property is important because it controls to a great extent the dynamic characteristics of clay minerals, that is, their reactions or their responses to environmental change. Kaolinite tends to be little affected by variations in the cation content and concentration of its environment because of its low cation-exchange capacity. On the other hand, illite, chlorite, and especially montmorillonite — all of which have a higher cation-exchange capacity and lower stability than kaolinite — will be affected to a greater extent by these changes.

Clay-water properties. The addition of water to clay minerals, resulting in the formation of a film of water on the outer surface and between the structural sheets of clay minerals, is a result of the negative charge distribution on the clay surface and the hydration of the exchange cations.[7,8] Many investigators have shown that this water film is oriented and actually bonded with the clay particle by a H^{+} bond, as shown in Fig. 6. The oriented or rigid water is considered to have a denser and more viscous character than ordinary liquid water.[2]

Thickness of this oriented water film will vary according to the type of clay mineral and the exchangeable cation. The film of oriented water is best developed and reaches the greatest thickness on the basal plane surfaces of the expanding lattice clay minerals (between plates). The next best development is found on the outer basal surface and the water film is least developed on the edges of the particles.[2] Only water and other polar liquids can develop this oriented layer.

The phenomenon of swelling in clays is a result of the influence exerted by the development of a water film on the basal plane surfaces of the expanding lattice clay minerals. This water film serves to separate individual plates and act as a lubricant between flakes.[7] Studies of the plastic properties of clays have shown that both the thickness and orientation of the water film are controlled by the adsorbed exchangeable cation.[1,7,9] The exchangeable cations Ca^{++}, Mg^{++}, and H^{+} increase the attractive force between particles, thus decreasing the thickness of the water film, while Na^{+} and Li^{+} decrease the attractive force between the plates, which allows more water to penetrate between the plates. Consequently, clay minerals carrying Na^{+} or Li^{+} exchangeable cations will display the greatest swelling or expansion ability.

Investigations of the expanding properties of montmorillonite and other expandable clays have shown that when Ca^{++} is the exchangeable cation, the clay will adsorb a well-ordered water layer which is only a few molecules thick. However, when Na^{+} is the exchangeable cation, the clay will adsorb a poorly-ordered water layer which is much thicker and causes the clay to expand or swell indefinitely.[2]

The relation between clay swelling and clay composition is most satisfactorily explained by the concept of cation dissociation.[10] According to this theory, the adsorbed cations tend to dissociate from the clay surface when the clay mineral is in contact with water, leaving some of the structural units negatively charged. Repulsive forces operate then to force the clay plates apart and permit the entry of water between them. The difference between the expanding properties of Na^{+} and Ca^{++} clays is, therefore, interpreted as an indication of less dissociation of the Ca^{++} than the Na^{+}.[11] Expandability of clays will also vary because of differences in structure and degree of degradation. The general order of expandability of the clay mineral groups is: Montmorillonite > degraded and mixed-layer minerals > illite > kaolinite. Montmorillonite shows the greatest expanding characteristic and kaolinite shows essentially no expansion when dispersed in water.[2]

Development of oriented water films

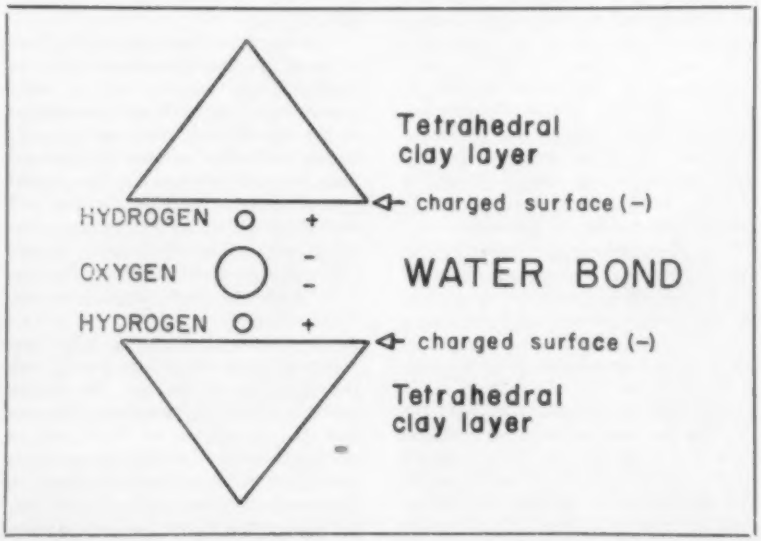

FIG. 6. **Schematic drawing** of configuration of ordered water binding adjacent clay layers.

on the outer basal surfaces of clay minerals was studied by Von Engelhardt and Tunn.[11] Their experiments indicated that montmorillonite and illite showed fluid adsorptions on the outer surfaces of the clay minerals far in excess of the amount adsorbed in intercrystalline swelling. They explained the orientation of this water by a process of osmotic equilibrium. The osmotic-equilibrium concept implies that the osmotic-equilibrium state of a semipermeable membrane surrounding the clay particles is the main factor controlling the amount of oriented water film on the outer clay surface. The main effect of this control is that, as the salt concentration of the fluid surrounding the particle is increased, the amount of bound or fixed water decreases. The bonding of water will also, as shown previously, depend upon the amount of dissociation of the clay-cation complex and upon the nature of the clay mineral. Von Engelhardt and Tunn[11] found that montmorillonite and illite showed an increase in the quantity of fluid adsorbed with a decrease in the concentration of electrolyte, but kaolinite did not.

Development of oriented water on the outer surface and between basal plates of clays is determined by the type of clay mineral, the base-exchange capacity of the clay, the type of cation, and the cation concentration of the surrounding fluid. A change in the environment of the clay particle, caused either by decreasing the salt concentration or by changing the type of cation in the fluid in contact with the clay, might cause an increase in the amount of oriented water and, in effect, increase the size of the clay particle.

Flocculation-deflocculation. A clay mineral is in a flocculated condition when the particles of clay tend to come together to form flocks or lumps, and it is in a deflocculated condition when these flocks or lumps are broken up or separated. The factors of major importance to the phenomenon of flocculation-deflocculation are the type and concentration of electrolyte present in the clay-water system, base-exchange effects, and the pH of the water.

The phenomenon of flocculation-deflocculation can best be explained by the double-layer concept.[12] According to this theory, when a clay mineral is added to a water solution containing an electrolyte, the ionization gives positively charged ions which may be, in part, exchangeable cations derived from the clay particle and negative hydroxyl ions. The hydroxyl ions $(OH)^-$ coat the clay surface, attaching themselves to the positive areas on the clay crystal and forming one layer. The counter cations (positive ions) form the second layer outside the hydroxyl ions. The clay particle, due to the action of the hydroxyl, is given a negative charge which is balanced by the positive counter ion.[12]

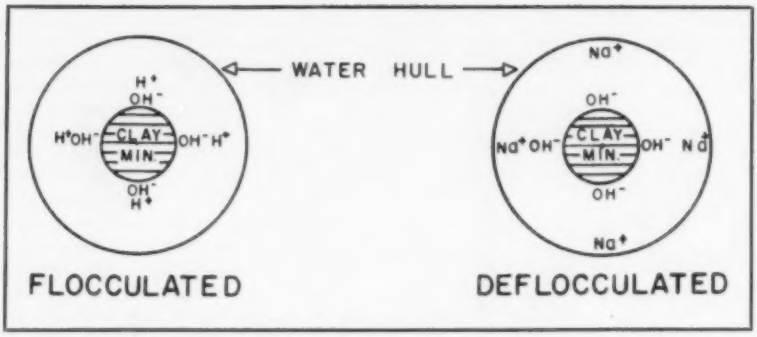

FIG. 7. **Flocculation-deflocculation** of kaolinite in clay-water system (after Hauser and Johnson[9]).

The extent of dispersion of the double layer is determined primarily by the character of the counter ion. The zeta potential, which is the electrical potential difference between the outermost continuous cation and the particle, is a measure of the thickness of the double layer. A clay mineral is flocculated when the counter ion is close to the clay particle. Maximum dispersion, or deflocculation, occurs when the counter ion has its greatest separation from the clay particle. These two conditions are illustrated in Fig. 7.

The basic effect of the counter ion in the flocculated condition is that the cation, due to its close proximity to the clay surface, neutralizes the negative charge on the clay surface, thus destroying the repulsive force between the clay particles. The counter ions Ca^{++}, Mg^{++}, H^+ adsorbed on the clay surface tend to cause flocculation, while the counter ion Na^+ causes deflocculation.

The degree of deflocculation or flocculation will also be controlled by the base-exchange capacity of the clay, concentration of exchangeable cations on the clay surface, and cation concentration of the fluid surrounding the particle. Hughes[13] pointed out that the degree of deflocculation-flocculation will also depend on the pH of the clay-water suspension. Both low pH and high pH promote flocculation, but medium high pH tends to promote deflocculation, or dispersion.

Clay minerals present in petroleum reservoir sands are in equilibrium with the formation brines and are usually found in the flocculated state. Entrance into the formation of fluid with a smaller cation concentration or of fluids containing deflocculation ions (such as Na^+) may lead to separation of clay particles adhering to the sand grains. These dispersed particles may then move to positions within the pores and form constrictions, thus decreasing permeability of the sand. It would be difficult, if not impossible, to return the dispersed clay particles to the flocculated state.[14]

Adsorption of organic compounds. Certain types of polar organic compounds found in oil sands can be adsorbed on the surface of clay minerals.[3] Because of their large size, these organic molecules may coat the exchange positions on the clay plates to such an extent that cation exchange is prevented. Adsorption of organic compounds will be controlled by the structure of the clay surface, replacements within the lattice structure, and cleanness of the clay mineral surface.[3] As a result, it appears that kaolinite would have little tendency to adsorb organic compounds, while montmorillonite would have very great adsorptive ability. Smoot,[15] in a study of clay minerals from sandstones found in Illinois, noted that some clays display a greater affinity for organic molecules than do others and in some cases the organic compounds could easily be removed, while in others they could not be removed, even after 48 hours of continuous washing.

The importance of these organic molecules coating clay minerals is that they protect the mineral from environmental change. However, if the organic material is removed during the production operation by chemically treated injection water, the clay is no longer protected and may expand or deflocculate and cause plugging of the formation.

Origin and Occurrence of Clay Minerals

The importance of clay minerals in petroleum production is shown by the fact that more than 50 percent of the material composing sedimentary rocks are clay minerals and 95 percent of all sedimentary rocks contain some clays.[16]

A detailed account of the origin and occurrence of clay minerals in sedi-

ments would be beyond the scope of this article and, therefore, the following discussion will be limited to a brief survey of the aspects of the origin and occurrence that are related to the accumulation and production of petroleum.

The clay mineral composition of many ancient sediments has been determined for deposits of varying age, distribution, and lithologic type. However, as Grim[2] points out, many analyses are incomplete because only the most abundant clay minerals were determined. Clays of the montmorillonite group are comparatively rare in sediments older than the Mesozoic, with the exception of some clays found in sandstones of Permian age in West Texas.[2,17] Montmorillonite is abundant in many sediments of Mesozoic and Cenozoic age and in Recent marine deposits. Many authors believe that most montmorillonites are formed by the alteration of volcanic ash which was deposited in the marine environment by hydrothermal alteration of sediments and by soil-forming processes.[2] Grim[2] states that the disappearance of montmorillonite in ancient sediments is due to their alteration to a mica-type clay mineral. In Cretaceous and later sediments montmorillonite clays are often associated with oil-reservoir sands.

Kaolinite clays are not found in abundance in early Paleozoic deposits.[2] Since kaolinite is most common in continental and nearshore Recent marine sediments, the lack of abundance in ancient sediments may be due to the fact that the older the geologic period, the more likely it is that these deposits would be destroyed by erosion.[16] Kaolinite is formed as a soil deposit under certain specific weathering conditions and it is the dominant clay mineral in the fluviatile environment.[2,16] Small amounts of kaolinite are found in the marine environment.

Clays of the illite and chlorite groups are the most abundant clay minerals in very ancient sediments.[2] Illite is universally present and often appears as the dominant clay-mineral component of Recent marine sediments. It is frequently the dominant component of many marine shales.[3] Weaver[16] points out that the chlorite clay minerals are seldom dominant in either ancient or Recent sediments.

Post-Depositional Alteration

Clay materials deposited with sandstones are mostly transported or detrital materials which are the product of erosion. During their accumulation in a new environment, these detrital particles may retain their mineralogic character or they may be altered in some way at the time of deposition and/or at some later time. Alterations or changes that occur tend to produce a mineral assemblage more in equilibrium with the new environment. Diagenetic changes that take place when a detrital clay mineral passes into a new environment are governed primarily by the character of the dissolved salts, the pH, the Eh and the organic content of the environment. Diagenetic reactions that modify the character of clay minerals are those that result in the following changes in the pre-existing material: changes in chemical composition, in basic lattice structure, in crystallinity, and in type of adsorbed cation.

Land-derived clays found in the fresh water fluviatile environment will consist mainly of degraded illite, degraded chlorite, mixed-layer structures, montmorillonite, and kaolinite. Chlorite and illite are found in this environment in the degraded state, primarily as a result of the partial leaching of potassium and magnesium brought about by the action of slightly acidic fresh water. Diagenetic changes of detrital clays in the marine environment promote the formation and regeneration of illite and chlorite which are in equilibrium with this environment, and lead to the partial destruction and/or conversion of kaolinite and montmorillonite which are not in equilibrium with the conditions of the marine environment. The degree of alteration of montmorillonite and kaolinite to illite and chlorite and the degree of regrading of chlorite and illite will be limited by the availability of potassium and magnesium, the rate of sedimentation, time of contact with marine water, the organic content, and the degree of pre-depositional alteration.[18]

The origin and distribution of clays in the marine environment is, however, not due entirely to diagenetic action. The influence of source material and the differential flocculation action of sea water may possibly overshadow the effect of diagenetic action.[16,19,20] Later post-depositional alterations taking place in sandstones and shales will be controlled mainly by permeability factors and the composition of formation waters. This type of alteration will be discussed in Part 2.

The factors of primary importance controlling the clay-mineral composition of sediments, as indicated by Morris and others,[6] appear to be: Relationship with the rock-forming minerals and solutions in the environment of deposition, and such post depositional changes as diagenesis, compaction, and lithification. There is considerable variation in the clay-mineral composition of various environments. The following table illustrates the clay minerals in each marine environment in the order of their relative importance.

Shelf Associations:
Stable — *illite (glauconite).*
Unstable — *illite, montmorillonite, kaolinite.*

Interior Basin Associations:
Open Marine — *illite.*
Arkose Deposits — *illite, kaolinite.*
Arid Restricted — *sepiolite.*
Black Shale Restricted — *illite.*

Geosynclinal
Without Volcanics — *illite, kaolinite.*
With Volcanics — *montmorillonite, illite.*

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TO BE CONTINUED

Part 2, dealing with the significance of clay minerals in oil reservoir sands, will be published in a succeeding issue of THE PETROLEUM ENGINEER.

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A new tool for the measurement of...

Gel Development In Drilling Fluids

Clay suspensions used as drilling fluids exhibit widely varying thixotropic properties. Here is an instrument that presents a possible means for determining yield point of drilling muds and measuring rate of development of gel strength

F. W. Jessen and Can Naci Toktar
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THE IMPORTANCE OF MAINTAINING proper viscosity and gel properties in a drilling mud fluid is well known. The true value attached to successful drilling and completion of the many deep wells drilled today is more significant when it is realized that, in large measure, the results obtained may be attributed to increased knowledge of the drilling fluids used and the development of specific properties for such fluids.

Again and again the engineer is confronted with the problem of varying conditions which occur during drilling that cause changes in the drilling fluid. One such factor is the control of gel strength. This is accomplished in several ways in field practice. Yet little is known about the rate of gelation in mud fluids of different types, nor how this rate may change due to contaminants, degree of dispersion, or use of special treating agents. The present work presents a possible means for determining the yield point of drilling muds with the Bendix Ultra-Viscoson and a method of using this equipment to measure the rate of development of gel strength.

Clay-Suspension Fluids

In a clay suspension, the particles orient themselves in a pattern to form a rigid gel structure. The strength of the gel is dominated mainly by the electrostatic force between the lattice structure of individual clay particles, which depends upon the cation present, the attractive force between the particles, and the size, number, and dissymetry of particles present in the suspension.

In any given clay suspension, the average distance between particles may be computed provided the average size of the particles is known and the assumption made that hydration is complete for the particular system involved. Numerous investigators[1,2,3,4,5,6] have shown the degree of dispersion in mud drilling fluids to vary widely. In fact, special drilling fluids have been developed which are characterized by controlled hydration and dispersion of the clay particles.

Equipment and Procedure

The Ultra-Viscoson[7,8] comprises a small probe, an electronic computer, and a connecting cable. Ultrasonic vibrations are excited by an electrical signal from an analog computer in a strip of special magnetostrictive alloy projecting from the end of a hermetically sealed tube. When the probe is immersed in a liquid, the metal strip acts as a source of transverse or shear elastic vibrations which radiate in the liquid. The frequency of the blade vibration is 28,000 cycles per second. Vibration is longitudinal, the maximum amplitude being 0.5 micron. The amplitude of the motion is further restricted by the viscous damping of the liquid in contact with the blade. Magnitude of the retarding force is dependent on the value of the product of the viscosity and density of the liquid.

In a clay suspension, vibrational energy imparted by the probe is effective in transmitting motion to the particles so as to break up the orientation of the latter and thus hinder the formation of gel structure. However, the input energy is opposed by the resistance offered to the propagation of the produced wave by the increased strength of the gel formation, which normally is reflected as an increase of viscosity by the generally accepted measurements such as obtained with the Fann V-G meter. As final gellation is reached, therefore, the instrument indicated viscosity readings become constant. At this point, the magnitude of internal forces of the gel just equal the external energy applied (which tends to break the structure of the gel) and, hence it appears possible to measure the rate of development as well as the ultimate gel strength. That is to say, the instrument may be utilized to show the rate at which gellation proceeds.

Procedure

Suspensions of commercial Wyoming bentonite of 2, 4, 6, 7, and 8 percent by weight were prepared, while 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, and 4.0 weight-percent suspensions of commercial magnesium montmorillonite clay were used. The prepared suspensions were set aside for 7 days so that hydration would be complete. Prior to testing, vigorous agitation with a high-speed mixer for 15 min was employed.

The plastic viscosity and yield point were determined with a Fann V-G meter, while the variation of the indicated viscosity (centipoises × grams per cc) with time was obtained with the Ultra-Viscoson. For the bentonite suspensions, the indicated viscosity readings were determined over a two-hour period, while for beneficiated magnesium montmorillonite suspensions the same readings were observed during

From a thesis by Can Naci Toktar submitted in partial fulfillment of the master of science degree in petroleum engineering, The University of Texas.

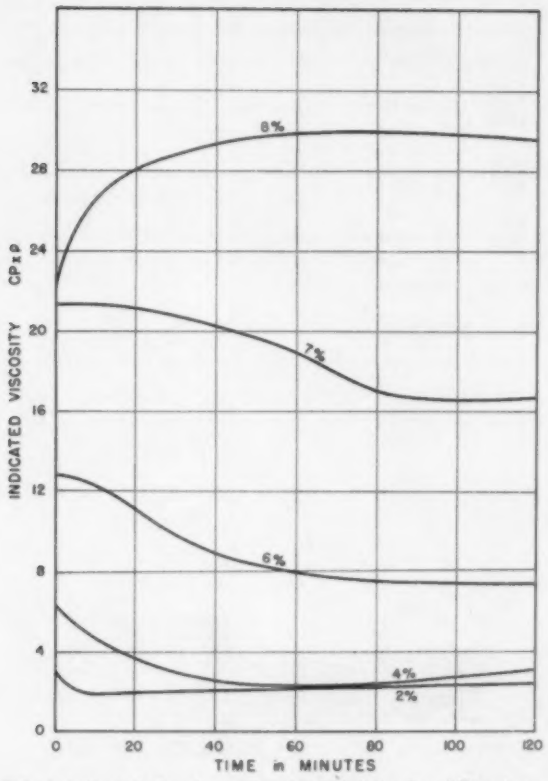

FIG. 1. Indicated viscosity vs time is plotted for five different suspensions of bentonite. Indicated viscosity is the product of viscosity in centipoises and density in grams per cc.

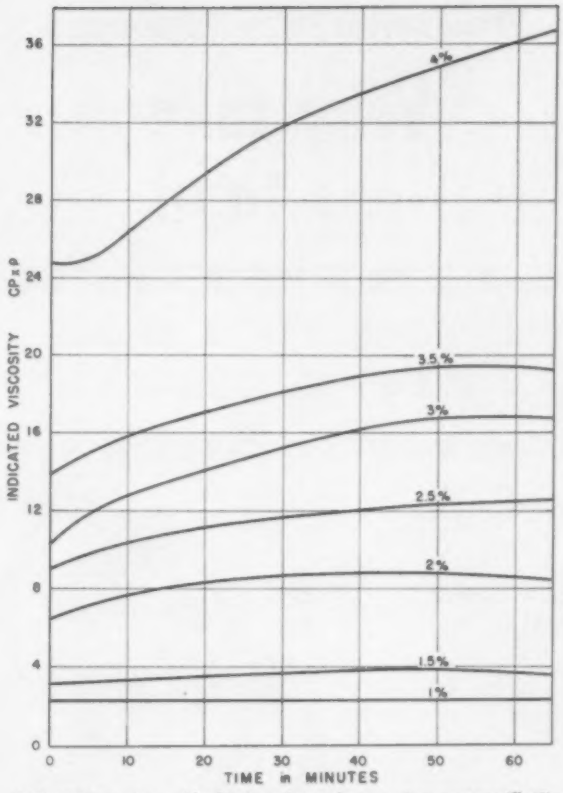

FIG. 2. Suspensions of highly beneficiated magnesium montmorillonite are presented in a plot of indicated viscosity vs time.

one hour only, since a constant reading was attained in that time with the latter suspensions. The viscosity and the 0-min and 10-min gel strength of each suspension were determined also with a Stormer viscosimeter. Chemical treatment was carried out with 10 percent solutions of a polymeric polyphenol derivation of hemlock bark, tannin, sodium acid pyrophosphate, and alkaline tannate in amounts equivalent to 0.221, 0.442, 0.663, and 0.884 lb per bbl respectively.

Two oil-emulsion muds prepared in the laboratory, a lime treated mud, and two field drilling muds were also used for viscosity and gel strength measurements.

Discussion of Results

The indicated viscosity values of the various clay suspensions are shown in Fig. 1 and 2. With 2, 4, 6, and 7 percent sodium bentonite suspensions, the indicated viscosity decreased with time, becoming constant after one hour. The time elapsed between the initial indicated viscosity and the indicated viscosity when a constant value was reached increased with the concentration of the suspension. The results with the 8 percent suspension showed an immediate increase in indicated viscosity which became constant after one hour.

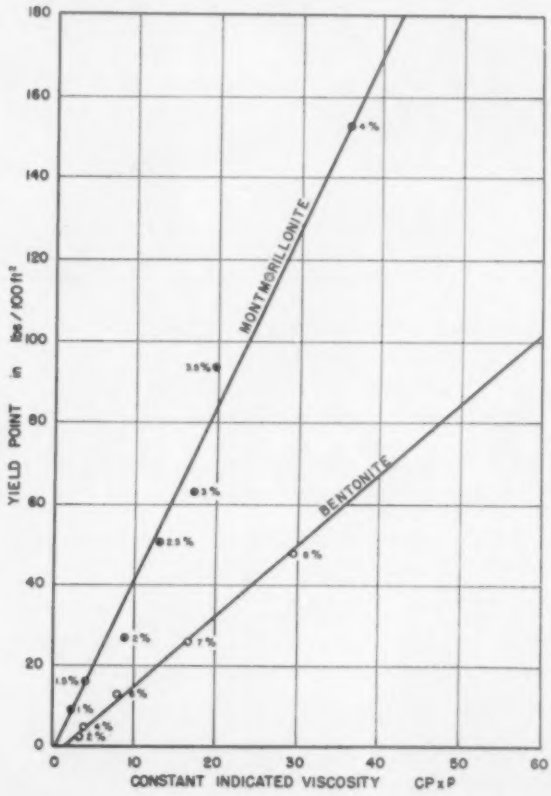

FIG. 3. Yield points of various montmorillonite and bentonite suspensions are in direct proportion to the constant indicated viscosity of the suspensions.

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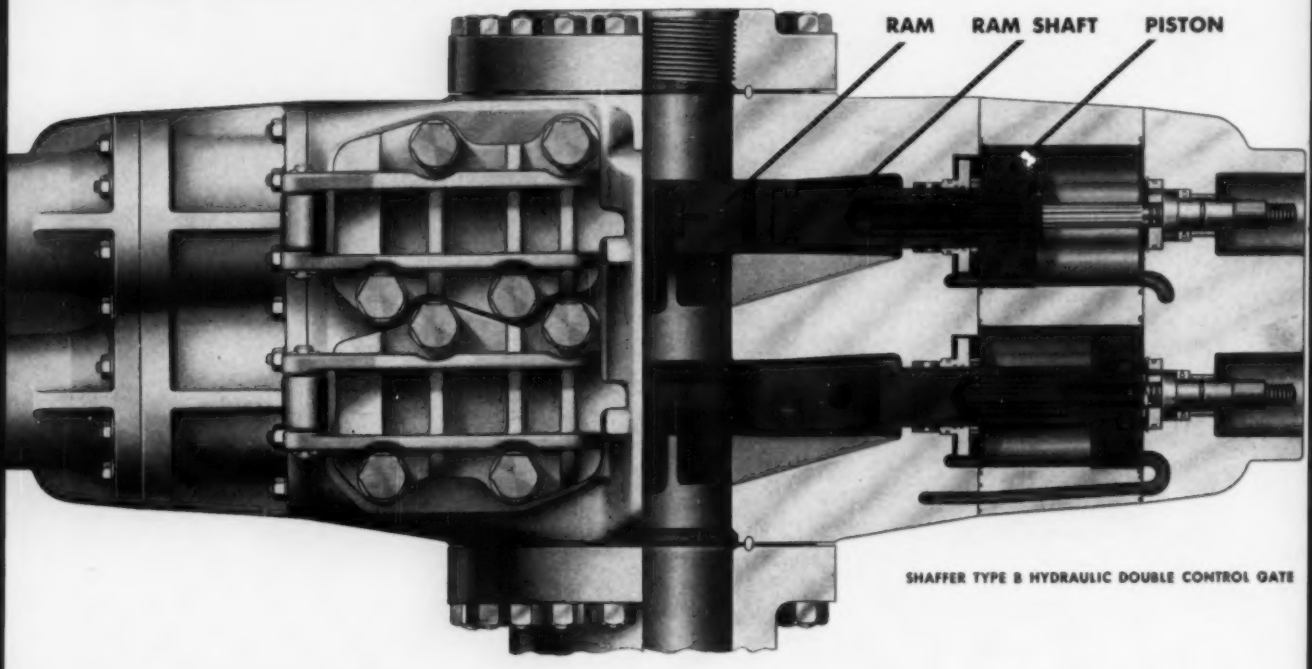

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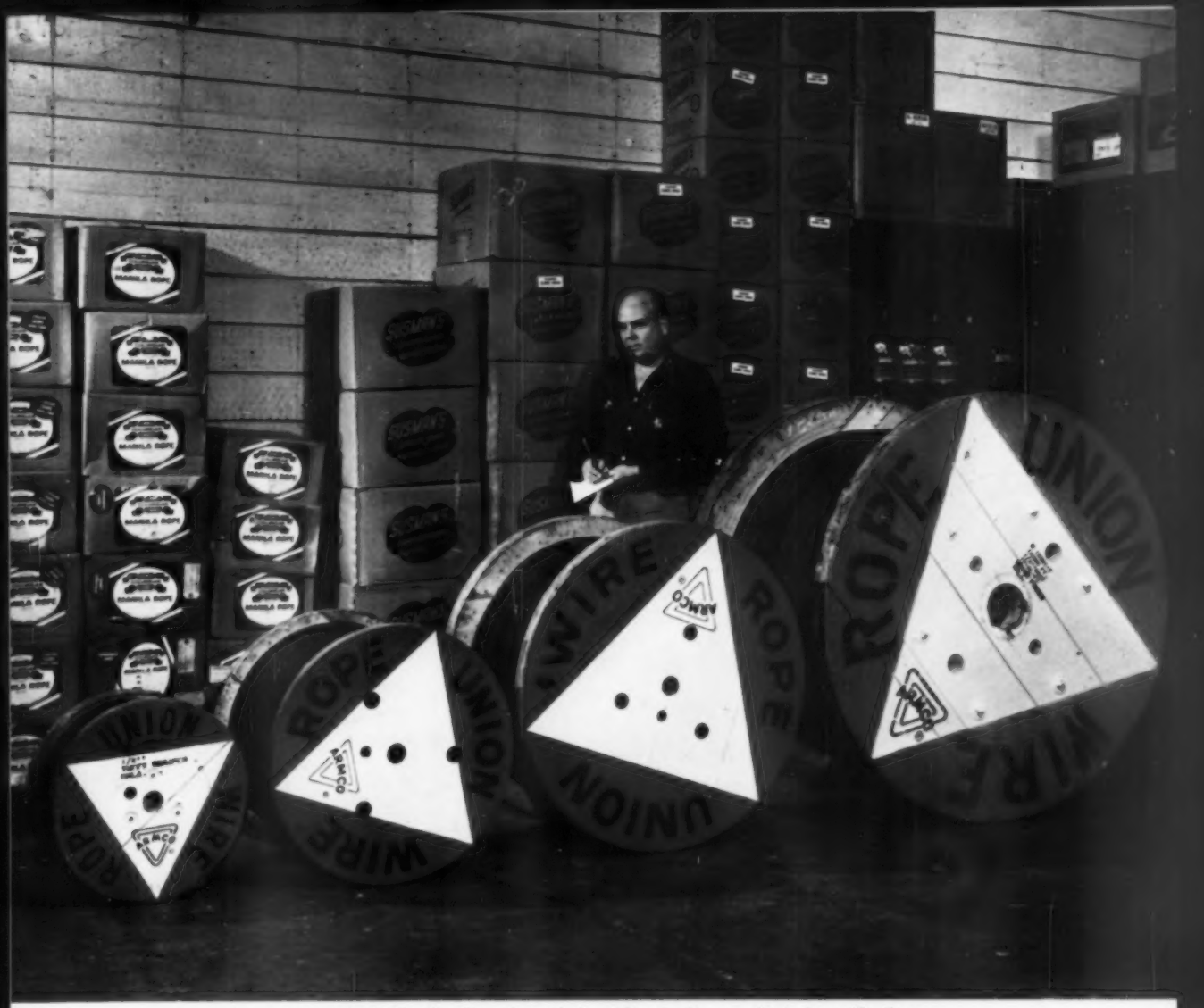

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Unitized drawworks—Except for a detachable front base section for reducing width to the 8-ft. transportation limit, the 80-B drawworks remains intact and completely assembled. (Remember, this is a 1,000 horsepower rig for 8,000 to 12,000-ft. drilling!) Controls, catheads and auxiliary brake are undisturbed. The 80-B transmission is three-speed, with two drives forward to the drum shaft.

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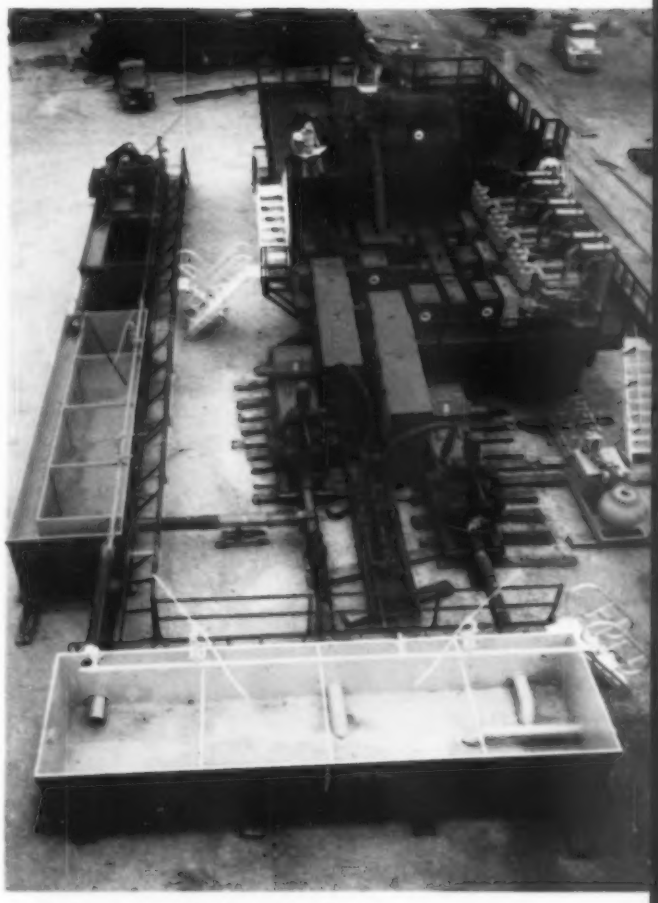
Take advantage of the compact rig design leadership you can see in National's 80-B drawworks—or any other National drawworks. Talk over your rig needs now with the National representative in your area.



Over-all view of the 80-B rig-up shows the three-section National Drive Group and two K-700 pumps.

More on the next page . . .

...and check these advantages of National Drive Groups!

Sectional Construction—A basic advantage pioneered by National, this insures unmatched and fast adaptability to various drilling and slush pump requirements. Drives are compact, factory pre-aligned, easy to move and rig-up.

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Optional Pump Drives—These include: Drives for one, two, or three slush pumps; V-Belt or chain drives to the pumps; Single or two-speed pump drives.

National Dy-A-Flex Air Clutches—Outstanding for rugged performance, these clutches are furnished for pump drives and, on rig drive groups, in the master clutch position.

Air Operated Controls—Air piping for controls is installed in the frames at the factory, permitting control of all rig functions from the driller's panel. These include controls for: engine throttles and clutches, pump drive clutches, master clutch and inertia brake, and (when specified) fluid drive scoops. Upon request, extra control locations can be tailored for any requirement.

Complementary Equipment—Integrally mounted air compressor equipment for the rig control system is standard. Other drives for generators, dual air systems, etc. can be furnished to your specifications.

Complete Factory Testing—All National Drive Groups are assembled, lubricated and test run prior to shipment. Surfaces are protected by rust preventatives and all exposed surfaces are painted.

The National Representative in your area will be glad to give you more information on National Drive Groups, Drawworks, and related auxiliary equipment. Ask him soon.

This drive group section of the 80-B rig shown on previous pages includes a National Auxiliary Drawworks Drive. Mounted on a countershaft on the front engine frame, the Auxiliary Drive permits all engines to operate as a single power unit while drilling, affording flexible power distribution to all driven components as required.

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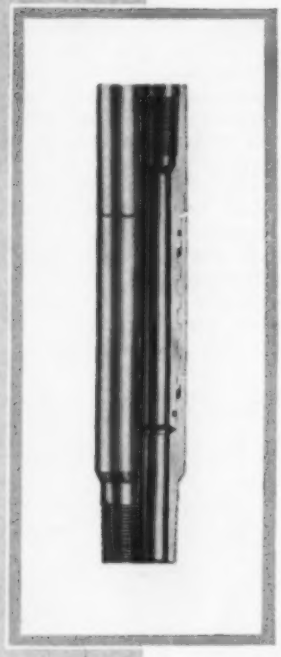

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At the beginning of each run, immediately after stirring, little or no orientation of the clay particles has taken place, and therefore, the values obtained by the instrument are more representative of the conditions existing in the absence of gel formation. With time, gel structure begins to form. The vibrational energy of the probe blade tends to impart motion to the particles. If the energy is sufficient, the particles will vibrate enough to overcome the gel forming forces, accounting for the decrease in indicated viscosity shown by the suspensions containing less than 8 percent bentonitic clay.

As the concentration of clay particles increases, the rate of development of a rigid gel structure increases. With the 8 percent bentonite suspension, a rapid and continually increasing rigid gel structure develops. Excitation of the particles become more difficult. When the strength of the gel structure exceeds the vibrational energy input, an increasing indicated viscosity is recorded.

Except in the case of the 4 percent magnesium montmorillonite suspension, the indicated viscosity increased with time until it reached a constant value. Fig. 2 shows that the suspensions behaved similarly to the 8 percent bentonite suspension. At lower concentrations the slopes were small whereas with increased clay content continuously increasing indicated viscosity values represent greater gel structure energies.

Fig. 3 shows a plot of the yield point of sodium bentonite and magnesium montmorillonite suspensions versus the constant indicated viscosity values. As observed, a good correlation exists between the constant indicated viscosity values and the yield point measured by the Fann V-G instrument.

Yield point values obtained from two natural drilling fluid samples, three laboratory prepared muds, and 7 percent bentonitic clay suspensions after treatment with chemicals plotted versus constant indicated viscosity values respectively are shown in Fig. 4.

Indicated viscosity values of bentonite and beneficiated magnesium montmorillonite suspensions (at the time when the viscosity becomes constant) versus time are represented by two parallel lines in Fig. 5. This indicates that these suspensions may have the same type of gel structure; however, the gelling rate of the montmorillonite suspensions is much more rapid.

Particle size. If the assumption is made that the size of the particles may be represented by an equivalent diameter, an average equivalent diameter may be obtained to indicate the average size of all the particles. Particle size distribution of a Wyoming bentonite has been determined experimentally by Mungan and Jessen.[9] A mean average diameter of 1.4 microns was obtained using an arithmetic average of all bentonite particles, while an equivalent diameter of 0.8 microns (maximum) results for the hydrated magnesium montmorillonite particles.[10]

From Table 1 it is apparent that the calculated distance between individual particles is of the same order of magnitude in beneficiated magnesium montmorillonite mixtures as in sodium bentonite suspensions having twice the amount of clay. That is, in equal concentrations, there is approximately twice the distance between particles in the bentonite suspension as in the montmorillonite suspension. Since interaction between particles primarily accounts for the yield stress, proportionately higher yield stresses should be observed in the latter type clay

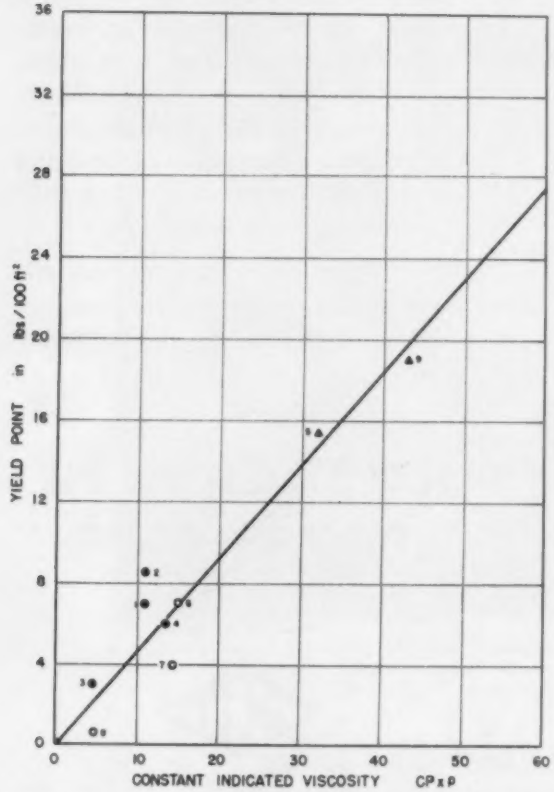


FIG. 4. Yield point values vs constant indicated viscosity for various clay suspensions: (1) 7 percent bentonite suspension treated with 0.884 lb per bbl polymeric polyphenol; (2) 7 percent bentonite with 0.884 lb per bbl tannin; (3) 7 percent bentonite with 0.884 lb per bbl sodium acid pyrophosphate; (4) 7 percent bentonite with 0.884 lb per bbl alkaline tannate; (5) field sample; (6) oil-emulsion laboratory sample; (7) lime-base laboratory sample; (8) oil-emulsion laboratory sample; (9) field sample.

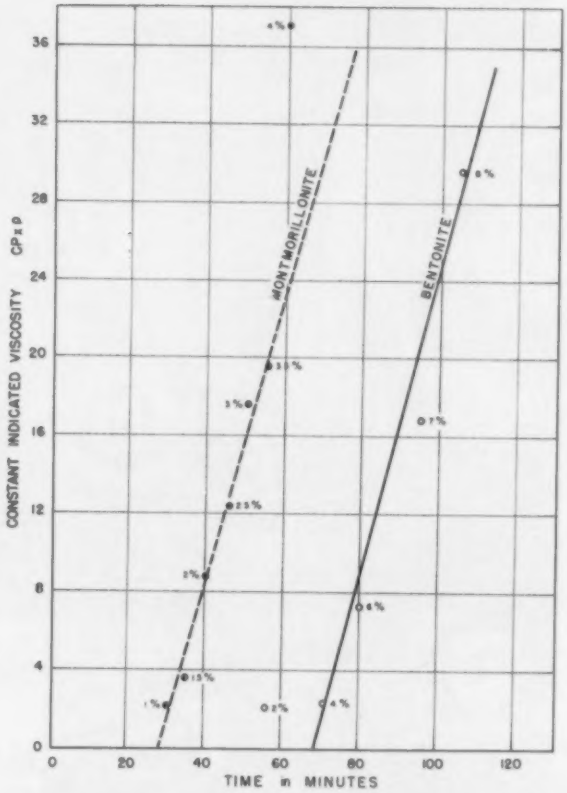
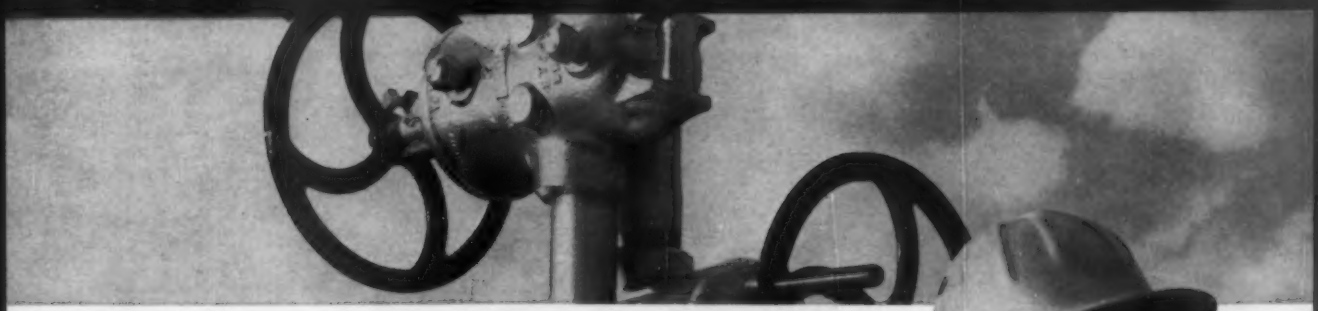


FIG. 5. Increase in gel strength as reflected by indicated viscosity as measured by the Ultra-Viscoson.



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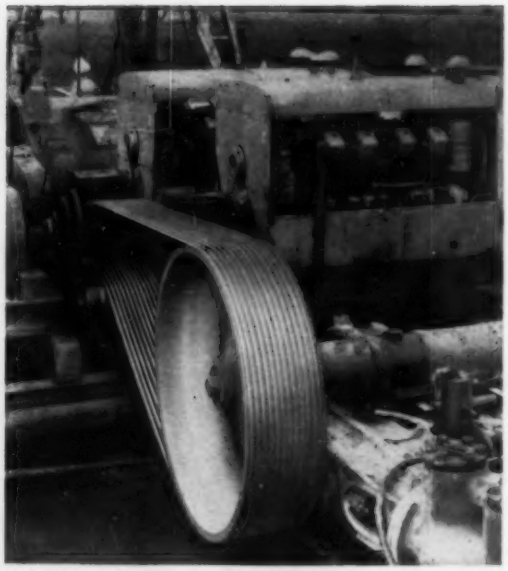

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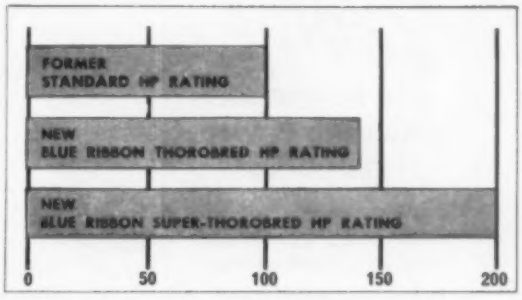

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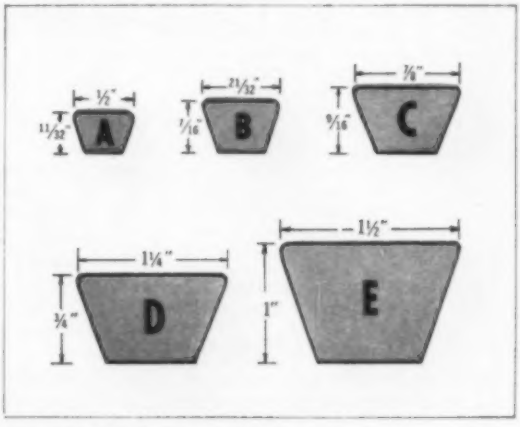

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TABLE 1. Physical Characteristics of Bentonite and Beneficiated Magnesium Montmorillonite Suspensions.

Bentonite suspension — percent	Average distance between centers — microns	Average distance between particles — microns	Average volume of clay particles — cc	Volume of water per particle — cc
2	20.65	17.85	1.435×10^{-12}	168.5×10^{-12}
4	10.20	7.40	1.435×10^{-12}	82.6×10^{-12}
6	6.74	3.94	1.435×10^{-12}	54.0×10^{-12}
7	5.75	2.95	1.435×10^{-12}	45.8×10^{-12}
8	5.00	2.20	1.435×10^{-12}	39.7×10^{-12}
Montmorillonite suspension — percent				
1.0	23.10	21.24	0.268×10^{-12}	63.7×10^{-12}
1.5	15.05	14.19	0.268×10^{-12}	42.3×10^{-12}
2.0	11.05	10.19	0.268×10^{-12}	31.5×10^{-12}
2.5	8.63	7.77	0.268×10^{-12}	25.0×10^{-12}
3.0	7.05	6.19	0.268×10^{-12}	20.8×10^{-12}
3.5	5.97	5.11	0.268×10^{-12}	17.7×10^{-12}
4.0	5.05	4.19	0.268×10^{-12}	15.4×10^{-12}

TABLE 2. Results Obtained with Fann V-G Meter and Bendix Ultra-Viscoson Using Various Chemical Treating Agents.

	Yield point from Fann V-G meter		Ultra-Viscoson values constant indicated viscosity		Corresponding yield point obtained from constant indicated viscosity values	
Treating agent	Initial	After treatment	Initial	After treatment	Initial	After treatment
7 percent Bentonite suspension						
(1)*	26.0	7.0	17.1	11.0	26.0	5.0
(2)	26.0	8.5	17.1	11.4	26.0	5.2
(3)	26.0	3.0	17.1	4.9	26.0	2.2
(4)	26.0	6.0	17.1	13.2	26.0	6.1
3 percent Montmorillonite suspension						
(1)	63.0	35.0	17.1	16.0	63.0	33.5
(2)	63.0	52.0	17.1	13.8	63.0	51.0
(3)	63.0	1.0	17.1	2.0	63.0	4.0
(4)	63.0	1.5	17.1	3.5	63.0	5.0
Drilling fluid sample from the Parker-Pearson No. 1 Well, Williamson County, Texas						
(1)	15.5	1.5	31.0	2.5	15.5	2.2
(2)	15.5	23.0	31.0	14.0	15.5	6.4
(3)	15.5	7.0	31.0	27.0	15.5	12.4
(4)	15.5	1.5	31.0	2.5	15.5	2.2

*(1) Polymeric polyphenol derivative of hemlock bark
(2) Tannin
(3) Sodium acid pyrophosphate
(4) Alkaline tannate

suspensions, simply from the closer spacing, regardless of the assymetry of the particles.[11] That the gel strength, however, is not dependent solely upon the proximity of particles is also forcibly shown in Fig. 3 and 5 where the data clearly reveals no direct relationship between particle spacing and yield point.

Dispersing agents. The effect of dispersing agents on various clay suspensions is shown by the data in Table 2. When the difference between the constant indicated viscosity values prior to treatment and the average values of the constant indicated viscosities after treatment were converted into yield point by use of Fig. 3, very close agreement with the values obtained by the Fann V-G meter resulted. The range of reduction of yield point obtained by the Ultra-Viscoson and the correlation of these values obtained with the Fann V-G meter indicates close agreement in yield values from 2 to 60 lb per 100 sq ft.

Conclusion

A good correlation exists between the constant indicated viscosity values obtained by the Ultra-Viscoson and the yield point values measured by the Fann V-G meter.

The Ultra-Viscoson may be employed to determine the yield point of various types of mud drilling fluids, and may be useful in determining the rate of development of gel strength.

Acknowledgment

The authors wish to express their appreciation and thanks to the Bendix Aviation Corporation, Cincinnati, Ohio, for furnishing the Ultra-Viscoson equipment used.

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Displacement in Multiple-Tubing String Wells

Various completion practices currently in use employ some equipment unique to multiple-tubing string wells. But certain trends in multi-string operation tend to offset the economic advantages of this type of completion

W. W. Word, *Assistant Chief Engineer, The National Supply Company, Houston, Texas*

MULTI-STRING COMPLETIONS are no novelty in the oilfields of the world. The motivating force behind the multi-string trend is economics.[1] The upward spiral of exploration, drilling, production and marketing costs has necessitated employing the most efficient and most economical depletion methods. It is expected that, percentagewise, the number of new multi-string wells will increase substantially and a large number of existing wells with a single producing zone will be recompleted as multiple producers with two or more tubing strings to save the cost of drilling another well. New equipment and new completion techniques have been developed which provide flexibility, economy and safety during operations. It is anticipated that future advances in equipment design will even further accelerate the growth of multiple tubing string wells.

The category, multiple string, applies to wells with a wide range of conditions. Tubing programs consist of two, three, or four strings of tubing from 1.660-in. OD to 3½-in. OD. In addition to the production tubing, a smaller parallel string (¾ or 1-in. nominal) can be run as a gas vent line, siphon string, or injection port to the casing annulus. The casing in which the parallel tubing strings are run varies from 4½-in. OD to 10¾-in. Shut-in tubing pressures range from 0 to almost 10,000 psi.

Because of the multiplicity of applications, most manufacturers of completion equipment have been required to design an infinite number of special purpose products, all of which fall into the general category of multi-string equipment. Regardless of the particular requirements, operators have insisted that the equipment for multiple string completions offers the same measure of protection which is available for single string installations.

Wellheads

Wellhead equipment has been developed in recent years which departs radically from previous concepts. Wellheads for two tubing strings are rather commonplace now; much design time by manufacturers is being spent on products for wells with three, four or more tubing strings. It is only a question of time until a quintuple or sextuple zone well is produced through separate tubing strings, providing of course, that it is economically feasible. Once the basic concept of multiple tubing strings is accepted, the question of how many strings can be run is governed only by the dimensions with which the equipment designers have to work. These dimensions are determined largely by the number and size of the tubing strings and the ID of the inner casing string.

Multiple wellhead equipment can generally be classified into two different types although there are many variations of each. One type of wellhead assembly is designed to work through blowout preventers with complete pressure control while the other type is not. With the first type it is possible to run, suspend, and pack off the tubing strings before the preventers are removed. A large percentage of the dual tubing string wells and practically all of the triple and quadruple string wells use this type of equipment.

The second type of wellhead assembly consists of simpler equipment for use on low pressure wells or pumping installations. The wellhead usually consists of a tubing head adapter with slip or mandrel suspension for the tubing strings. Connections for preventers are sometimes provided so that the second (or third) string can be run with preventer protection, but quite frequently the tubing strings are run without any conventional control equipment installed. One manufacturer produces a dual stripper rubber which is used when running or pulling the tubing.

Packers

One of the chief reasons for using parallel tubing strings for production, rather than one tubing string and the casing annulus, is to keep both high pressure and corrosive fluids isolated from the inner casing string. In dual parallel completions, to separate the upper zone production from the casing, it is becoming common practice to set an upper packer in addition to the lower one, although there are still some installations in which only one packer is used.[2]

A variety of packers are manufactured which were specifically designed for, or can be adapted to, multiple string wells. They can be generally separated into two broad categories; permanent (drillable) and retrievable packers. Where two or more packers are required, permanent and retrievable packers can be used in combination, if desired. There are advantages and limitations to both types; the selection of the packers for any well depends on many variable factors. One theory regarding the choice of permanent or retrievable packers is that known drillability is more desirable than questionable retrievability.[3] Under certain conditions this might be applicable; however, there have been great advances in retrievable packer

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design within recent years. The oil industry needs a packer which provides the advantages of both permanent and retrievable types.[4]

One point to be considered in selecting the method of landing tubing in a packer is the effect of external forces on the stress level in the tubing string. Assuming that tubing weight is slacked off on the packer in order to maintain the annulus seal, an increase in the tubing length caused by an increase in temperature or by a decrease in the pressure differential between tubing ID and casing annulus will add to the compression load on the tubing string. The compressive stress can cause the tubing string to buckle, leading to interference with the other tubing strings and/or preventing the passage of tools within the tubing. Compressive stresses are also conducive to tubing joint leaks.

Use of mechanical hold-downs to anchor the tubing string within the packer presents the possibility of the other extreme. Assuming the tubing is suspended in tension through the use of a mechanical anchor, a decrease in temperature or an increase in the pressure differential between tubing ID and casing annulus will add to the tensile load; it could conceivably cause the tubing to part by exceeding the joint strength.

DISPLACEMENT METHODS

One of the primary differences in single and multiple tubing string completions is the method of displacing the mud within the tubing string after the tubing has been suspended within the wellhead and a means of pressure control installed. Since the use of a packer or packers is almost mandatory for dual producers, displacement presents problems similar to single string installations with a packer.

Single String Displacement

With a single tubing string, the tubing is ordinarily run through blowout preventers mounted on the tubing spool. After running, the tubing string is spaced out so that the seal nipple will be properly spaced within the packer. A stuffing box top of tubing hanger is made up on the last tubing joint and lowered through the blowout preventers until the tubing hanger reaches its seat in the tubing spool. The landing joint is retrieved, leaving the tubing supported by a coupling resting on the tubing hanger. The blowout preventers are then removed, the tubing string picked up, and a Christmas tree is made up on the male thread of the tubing after the coupling is removed. The Christmas tree and tubing string can be picked up sufficiently for the seal nipple at the lower end of the tubing string to be disengaged from the packer bore. Water or oil is pumped down the tubing string to displace the heavier mud which is circulated up the annulus between the casing and tubing and out the tubing spool outlet. The stuffing box tubing hanger which seals between the tubing spool and the tubing is designed so that the tubing can be moved through it while still maintaining a pressure seal. After the mud is displaced with a lighter fluid, the Christmas tree and tubing are lowered down until the Christmas tree can be bolted to the uppermost flange of the tubing spool. Since the tubing string has previously been spaced out, the seal nipple is simultaneously positioned properly within the packer bore. Formation pressure is often sufficient to overcome the hydrostatic head imposed by the column of water or oil within the tubing and the well starts producing. The Christmas tree, having been previously installed, provides control of the well pressure.

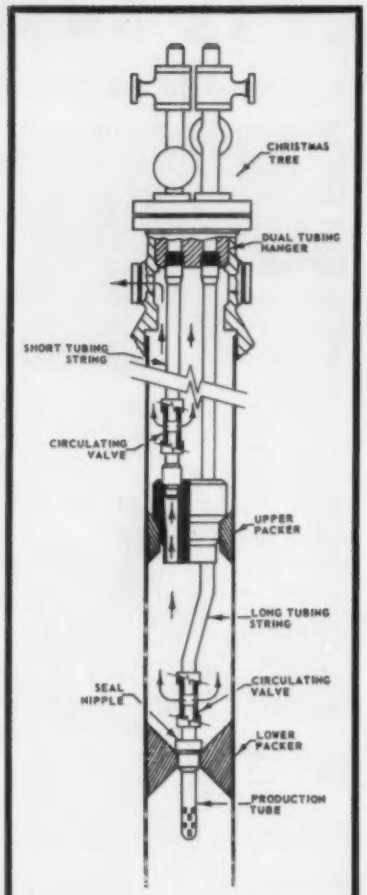

FIG. 1. Multi-string displacement in a two-packer well is completed by circulating valves run between packers on long tubing string.

Multiple String Displacement Methods

The above completion method with slight variations has been used for numerous years for single tubing string wells where a packer is used. The same requirement for displacement exists on all multi-string installations; however, because of the space limitation, the procedure is somewhat more involved. Listed below are several displacement methods which are currently being used for multiple string completions. Since the wellhead equipment, packers, and accessory down-hole equipment will, in some instances, limit the displacement methods which can be employed, consideration should be given to these points in pre-well planning and equipment specification.

Swabbing. After the two tubing strings have been suspended and the control equipment (Christmas tree) installed, the weighting material within the tubing strings can be removed by a wire line operated swab. The swab and a sinker bar which adds weight are lowered through the fluid inside the tubing and then pulled out, thus bailing out the fluid above it. The number of trips required to lighten sufficiently the hydrostatic head imposed by the mud depends on the weight of the mud, the depth of the well, and the pressure of the formation. There is always a possibility of the swab getting stuck at some restriction within the tubing string thereby causing delay in the completion. Because of the time requirements and other factors, swabbing is not ordinarily used for displacement in deeper wells.

Circulating valves. Use of wire line actuated circulating valves run on the tubing string permit the displacement of mud within the tubing string with complete pressure control. Circulating valves can be used several different ways. In a two-packer well, a circulating valve can be run into the well between the packers on the long tubing string as shown in Fig. 1. After the short tubing string is set and the Christmas tree is installed, mud can be displaced by pumping down the long string, out the sleeve valve and up the short tubing string. When the displacement is completed, the valve is closed by a tool run on a light wire line.

A variation of the above method is the use of two sleeve valves; one positioned on the long tubing string between the packers and the other on the short tubing string above the upper packer. This arrangement permits the displacement of the mud within the casing annulus with water or oil. Having water or oil in the annulus is sometimes desirable to help prevent corrosion of the

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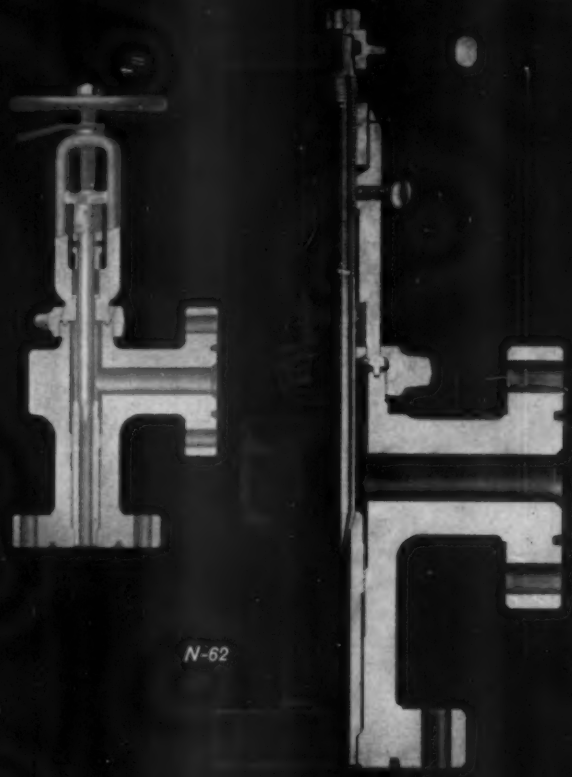

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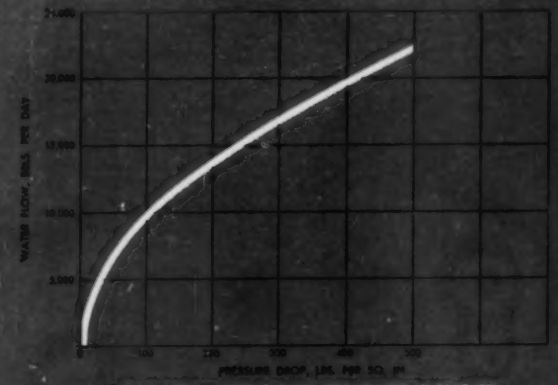

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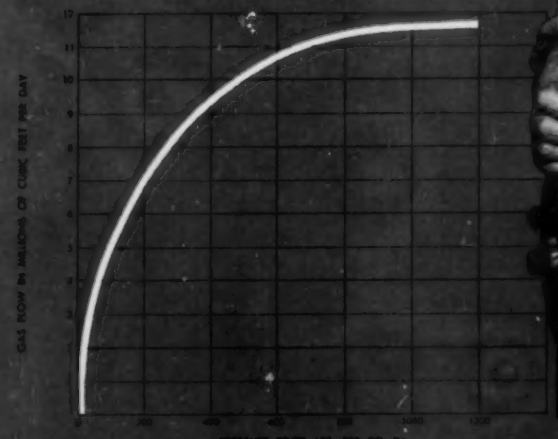

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casing or to facilitate removing the tubing or the packers at a later date.[6]

Tubing string manipulation. As pointed out previously, in single completions which utilize a packer, it is common practice to disengage the seal nipple from the packer by picking up the tubing and circulating after suitable surface control equipment has been installed. With multi-zone completions, this basic principle is practiced even though the procedure is more complicated.

Individual tubing string manipulation. During individual tubing string manipulation, the long tubing string is usually displaced after it is run into the well prior to its suspension in the tubing head. If the production tube below the packer seal nipple is short enough, communication with the lower formation is prevented by a spring loaded flapper valve or some other type of back pressure valve in the lower packer. When the seal nipple and production tube are withdrawn to circulate, the valve automatically closes, isolating the lower zone production from the casing annulus. After displacing, the production tube and seal nipple are lowered down into the packer bore, opening the valve. Pressure control at the surface is provided by either a back pressure valve within the tubing or tubing hanger or by the master valve of the Christmas tree, depending on the type of equipment which is selected. Back pressure valves are available from most wellhead manufacturers which allow fluid to be pumped down the tubing bore but prevent a back-flow. These valves can be removed through the Christmas tree under well pressure.

After the long string is run, displaced and suspended, the identical procedure is followed with the short tubing string. Again pressure is controlled by attaching the tubing to the Christmas tree or through use of a back pressure valve. After the mud is displaced, the tubing string is lowered so as to position the seal nipple within the packer bore and the Christmas tree is installed. If the formation pressure is not sufficient to bring the zone in even after replacing the mud with lighter fluid, the fluid column will require swabbing or agitation by other means.

Simultaneous tubing string manipulation. Another method of displacement is gaining acceptance throughout the industry. After both tubing strings have been run, spaced, suspended, and the Christmas tree installed, the lowermost flange of the wellhead body is unbolted as shown in Fig. 2. A lifting flange is attached to the top portion of the Christmas tree and both tubing strings, together with the Christmas tree, are picked up far enough to withdraw the seal nipples from the packers. After lifting the tubing spool and Christmas tree, a dual stuffing box type of tubing hanger is wrapped around both tubing strings and seated in the bowl of the wellhead body. (Fig. 3) The annulus around the tubing strings is sealed by the stuffing box hanger packing which is actuated by anchor screws in the wellhead body upper flange. With both tubing seal nipples clear of the packers and the casing annulus sealed, water or oil can be pumped through the Christmas tree into the tubing string, up the casing annulus and through the outlet of the wellhead body. After displacement, the Christmas tree and the attached tubing strings are lowered until the tubing spool flange can be bolted into correct position. (Fig. 4) Simultaneously, the seal nipples engage the packer bores to effect a seal.

The advantage of this method of displacement is that the entire completion is accomplished under control. The tubing strings are run and suspended with complete blowout preventer protection. The circulating is done through the Christmas tree with one or more valves for protection in case the well starts producing prematurely.

Hydraulic set packers. Still another method of multiple displacement which has recently been introduced utilizes hydraulic set packers. One of the foremost requirements for any completion method is complete protection against blow-outs. Hydraulic packers enable the operator to have a controlled multi-string completion from the time of

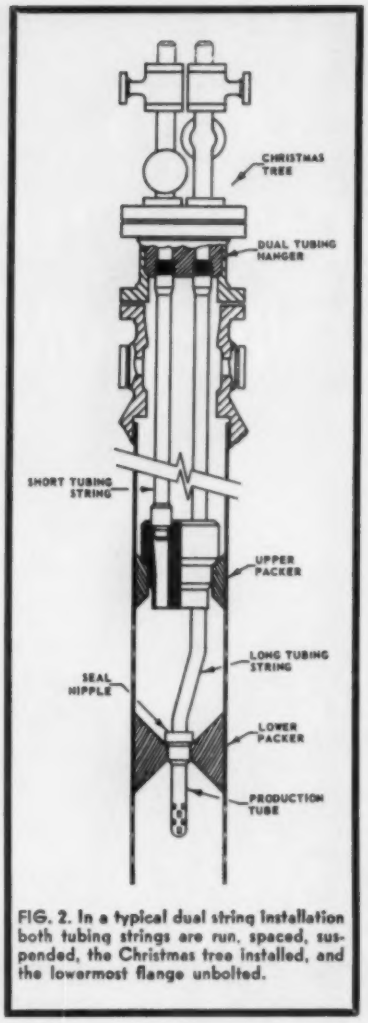

FIG. 2. In a typical dual string installation both tubing strings are run, spaced, suspended, the Christmas tree installed, and the lowermost flange unbolted.

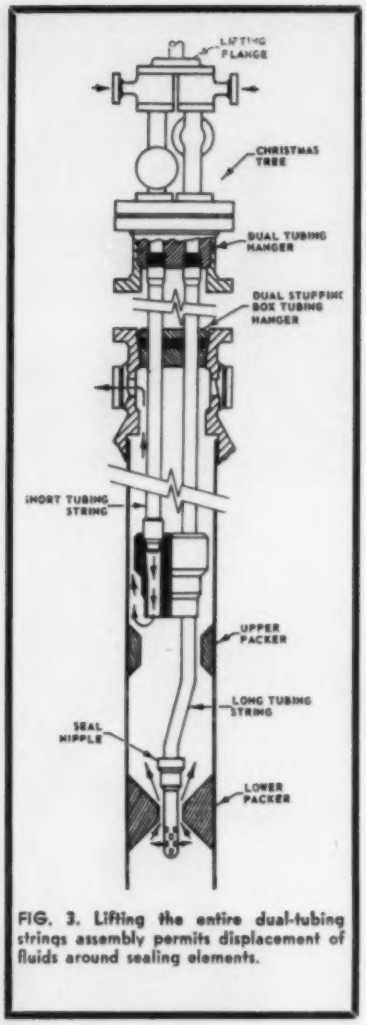

FIG. 3. Lifting the entire dual-tubing strings assembly permits displacement of fluids around sealing elements.

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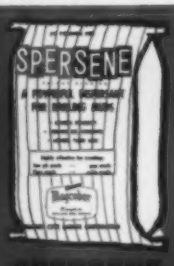

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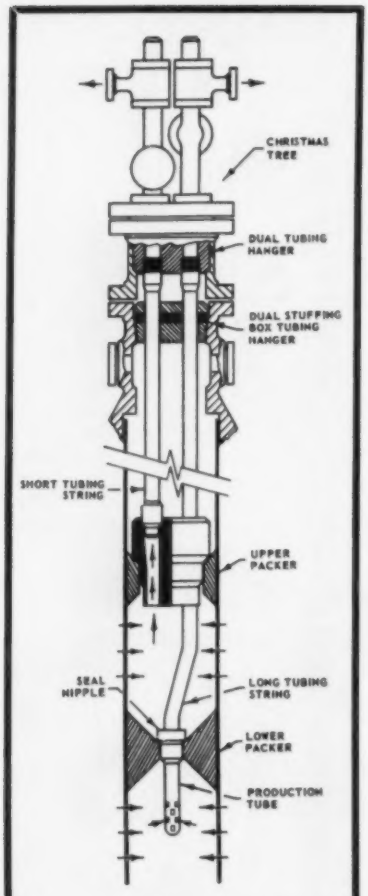

FIG. 4. After displacement, the Christmas tree and attached tubing strings are lowered until the tubing spool flange can be bolted into correct position.

running the tubing until the zones start producing.

The chief difference between this method and others previously described is that it is not necessary to pick up the tubing strings in order to displace; the packers are not set until the mud is circulated out of the tubing strings. The packer is set when required by hydraulic pressure from the surface.

These displacement methods are most commonly in use at present. Although the procedures and the illustrations deal mainly with two strings of tubing, the displacement methods outlined would be equally applicable to wells with three or four tubing strings. Wellhead equipment for simultaneous manipulation of three tubing strings has already been developed; it would be relatively simple to design comparable equipment for four strings of tubing if it is not already a reality. The equipment used when displacing by swabbing or by circulating valves is the same regardless of the number of tubing strings in the well.

Quadruple tubing string wells on which information is available have either been swabbed in or have had the mud displaced by circulating after the installation of the Christmas tree. This was achieved through the use of hydraulic set packers as described above.

Design Limitations

In the relatively short time that parallel completions have been widely practiced, there has been a constant trend toward increasing the size or number of the tubing strings and decreasing the size of the casing in which they are run. This is in agreement with the economy concept of multi-string completions; however, as the trend continues, it imposes severe limitations on the designers and manufacturers of packers, wellhead equipment, Christmas tree valves, and similar material. Because of the space limitation, it has been necessary to sacrifice some of the design features of comparable single string equipment. Stresses are higher and, in general, the equipment requires much more care in installing to avoid damage.

To illustrate this point more fully, consider a typical wellhead installation. One conventional tubular program is two strings of 2⅜-in. OD tubing within 7-in. casing. Most wellhead manufacturers provide a 6-in. nominal tubing head and dual tubing hanger to accommodate this combination. A 6-in. nominal tubing hanger must be less than 7⅛-in. OD in order to pass through a standard 6-in. blowout preventer. The body member which supports the dual tubing hanger must have a 6⅜-in. minimum bore to be full-opening for the casing. Since, in a normal completion cycle, tubing couplings are passed through the hanger, it is necessary to provide within the hanger two ports, each larger than 3⅛ in., making a minimum of 6⅛-in. port diameter within the 7-in. diameter hanger. In addition to clearance for the tubing strings and collars, some types of tubing hangers provide for passage of side pocket gas lift valves and similar tools.

It is also necessary to support the tubing hanger within the tubing spool body, to furnish a locator mechanism for orienting the tubing ports with respect to the tubing spool and to seal the annulus by means of a packing unit.

This is a typical example of the design problem encountered by wellhead manufacturers. With two long tubing strings and the possibility of an additive pressure load applied on top of the tubing hanger (in the event of a tubing bore seal failure), it is obvious that the capacity limit for hangers of this size is rapidly being reached. Wellhead designers are trapped between a fixed area for supporting the tubing strings and increasing tubing and pressure loads.

The problem of diminishing design area is not confined to wellhead products alone but affects Christmas tree valves, packers, gas lift valves, and other completion tools. Service companies have had difficulties attaching their lubricators to the top of high pressure dual Christmas trees because of the dimensions dictated by current practices.

Recommendation for New Wells

In spite of the dimensional demands made of present multi-string equipment, it has proved adequate for initial installations. What has not been fully determined is whether future workover programs can be carried out without delays caused by malfunctioning equipment. No doubt better equipment (valves, wellheads, packers, etc.) could be furnished if larger casing were run than that currently being used. Since this would increase the cost of new wells and is impossible in the case of old wells that are recompleted as duals, it is not likely that this practice will become popular.

As a less expensive alternative, if two or three joints of larger casing could be run at the top of the oil string, it would greatly ease the design problems of the wellhead and Christmas tree valve manufacturers even though the space limitations confronting the designers of packers and downhole equipment would be unchanged.

It is the aim of every equipment manufacturer to provide the tools with which the most efficient completions can be made, but conversely, it should be every operator's responsibility to ascertain that his completion method allows the most efficient and economical utilization of these tools. Any completion practice or tubing program which reduces the equipment cost (and flexibility) at the expense of ruggedness and ease of installation is not the most economical one over a long term.

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Determination of native surfactants . . .

TENSAMMETRY: Key to Reservoir Wettability Studies

Natural surface active agents in some oil field brines and crudes can have a marked influence on reservoir wettability. Here is a method of determining such surfactants and the results of tests of fluids from various fields

Royal A. Todd
and
George W. Crawford
Texas Petroleum Research Committee, Austin, Texas

OIL-BEARING RESERVOIRS may be classified as preferentially oil-wet or preferentially water-wet. The condition may control oil recovery and the oil-recovery process. Therefore, the question of what makes a rock oil-wet or water-wet assumes great importance.

Recently,[1] some 40 different oilfield brines from 16 different formations of various geologic ages were examined by a new polarographic technique called tensammetry in an attempt to correlate the wettability of the formation with surfactants in the brines. Some brines apparently contained no surfactants. The crude oils produced from the same reservoirs as the brines which did not contain surfactants were tested. Of the 10 different crude oils tested from 6 different formations, the tensammetric response curves of each of the oilfield brine-crude oil mixtures — representative of the Wilcox sand of the Oklahoma City field, Simpson formation; the East Texas field, Woodbine formation; and Dickinson, East White Point, Midway, and Plymouth fields, Frio formation — contained a peak having all the characteristics of peaks caused by adsorption-desorption phenomena.

A study was carried out to determine if these tensammetric peaks[2] could be caused by a hydrocarbon constituent of the crude oils. The three more common types of hydrocarbons found in crude oils, i.e., paraffins, cycloparaffins, and aromatics,[3] were examined in the tensammeter using the same technique employed in the study of the oilfield brine-crude oil mixtures but using a 0.1 NaCl brine for an electrolyte. Although olefins are rarely present in crude oils, representative olefins were included in the study.

This study is part of a continuing effort to relate the surface active agents present in oilfield fluids to the wettability of the rock matrix. As anaerobic sampling and testing conditions were not maintained, the possibility that the surfactant detected may have been created by chemical reaction is fully recognized.

Theory of Tensammetry

Surfactants. The interfacial energy and interfacial charge characteristics of a liquid-liquid or a liquid-solid system are governed primarily by the chemical nature of the components present in each phase and secondly by pressure and temperature. The addition of any solute will generally alter the interfacial energy of the system, but certain solutes have the property of altering the interfacial energy to an extreme degree by greatly lowering the surface energy of their solvents. Substances which produce this effect are known as surfactants. The term surfactant is used rather loosely to designate any substance whose presence in small amounts markedly alters the surface behavior of a given system.

A large number of surfactants are characterized by a molecular structure which is essentially linear, having one end of the linear structure composed of radicals which are compatible with the solvent system and the opposite end of incompatible radicals. Usually one end comprises a hydrocarbon radical of hydrophobic nature characterized by weak residual valence forces. Many other substances do not have the unbalanced hydrophilic structure, yet have pronounced activity in emulsification, detergency, wetting, and other surface phenomena.

Tensammetry. Tensammetry, as developed by Breyer and Hacobian,[4] is a method of investigating the surface activity at a mercury-electrolyte interface by measuring alternating current as a function of applied direct-current voltage. Surface active substances are spontaneously adsorbed at the mercury-solution interface and are desorbed when the potential across the interface is great enough. The alternating current is low throughout the entire voltage range in which the molecules are strongly adsorbed on the electrode. The applied voltage at which the greatest number of molecules are in this state of immobile adsorption is the electrocapillary zero point, E_o.

As the potential difference across the interface is increased from E_o, either

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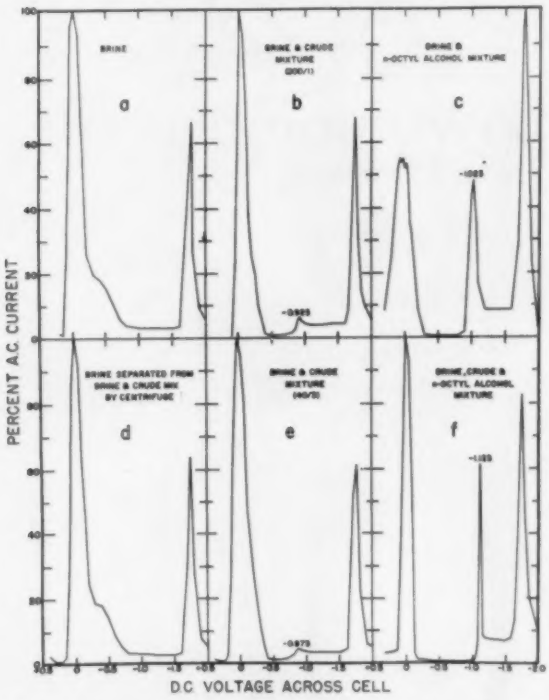


FIG. 1. **Tensammetric response curves** of Oklahoma City field fluids. The Wilcox sand of this field is generally considered to be preferentially oil-wet.

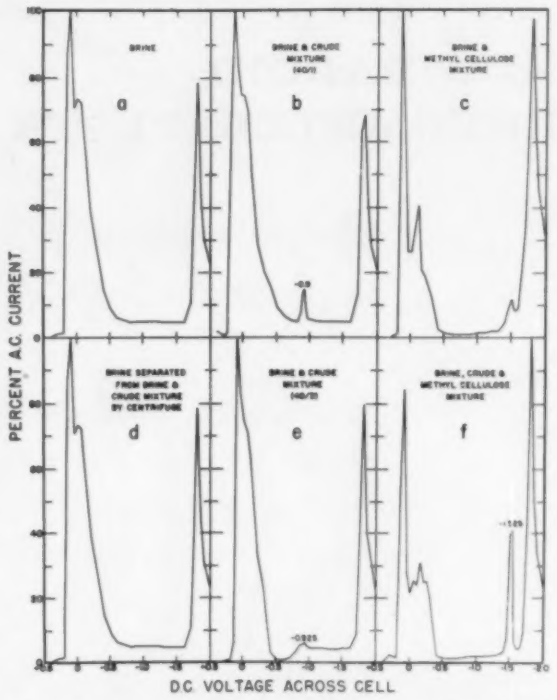


FIG. 2. **Response curves** of the fluids taken from the Dickinson field are characterized by the absence of tensammetric peaks, denoting a lack of native surfactants.

in the positive or negative direction, the surfactant continues to be tightly adsorbed until a narrow band of potential difference is reached in which the desorption force of the applied voltage is balanced by the adsorption force. In this narrow band, the relatively high resultant alternating current is caused by adsorption-desorption equilibria of the surfactant in the region of active space near the electrode and without actual electron transfer across the electrode boundary.

A further increase in the potential difference frees the now desorbed surface active molecules resulting in an alternating current which, although higher than the current in the voltage range where the surfactants are adsorbed, is much lower than the current in the voltage range of adsorption-desorption equilibria. When the resultant alternating current is plotted versus direct current voltage, the tensammetric adsorption-desorption equilibria "peaks" bound the adsorption "valley." The portions of the response curve outside the tensammetric peaks are due to the electrolyte. Frequently the desorption-side slope of the positive tensammetric peak overlaps a non-tensammetric peak, partially concealing the tensammetric nature of the peak.

Response curves. The response curve of an electrolyte which does not contain a surfactant exhibits three peaks (Fig. 1-a) none of which are due to surface active phenomena. The strongest peak[5] is due to a reversible reduction of O_2 to H_2O_2 and occurs near zero applied direct-current voltage. The second, an ionic peak, varies in position with the composition of the electrolyte. The third peak is due to the decomposition of the water molecule and varies from -1.75 to -2.20 volts according to the composition of the electrolyte.

The peaks produced by a surfactant (tensammetric peaks) have four identifying characteristics when compared to the peaks produced by the electrolyte (polarographic peaks):

1. Except for very low or very high bulk concentrations of the surfactant, the peaks are narrow and sharp. The position of a tensammetric peak can be determined to within ± 0.005 volts.

2. The base current on the adsorption side of the peak is lower than the current on the desorption side.

3. Adsorption-desorption equilibria phenomena cause a change in the wave form of the alternating current. The form wave change is different for different surfactants.

4. If the supporting electrolyte contains more than one surfactant, only the response peaks of the surfactant which is more strongly and hence preferentially adsorbed on the electrode are obtained superimposed on the response curve of the electrolyte.

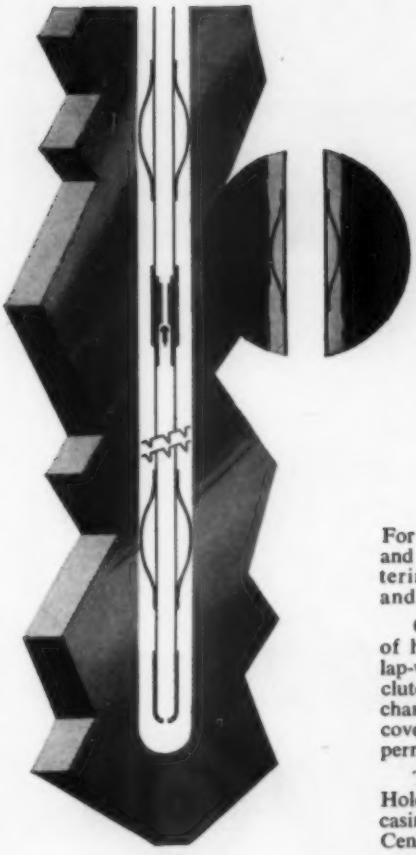
For an insoluble surfactant, the potential difference appears to be independent of the bulk concentration of the surfactant as mixed with the electrolyte. For a given electrolytic composition, E is quite reproducible.

In a study in which a substance of purity less than 100 percent is added to a surfactant-free electrolyte, the tensammetric peaks may be due to: (1) the substance added, (2) an unknown impurity in the substance, or (3) a surfactant created by chemical reaction either with the air, with the electrolyte, or at the mercury electrode.

Test Procedure

A brine-crude mixture suitable for use in the tensammeter is prepared by mixing thoroughly a chosen amount of the crude oil with 200 cc of its brine in a high-speed mixer. After separation of the excess oil by gravity separation, a sample is withdrawn from the lower part of the mixture and transferred to the tensammetric cell. A tensammetric profile is then obtained for comparison to that of the brine.

A hydrocarbon brine mixture is then prepared by mixing 2 cc of research grade hydrocarbon with 200 cc of a 0.1 N NaCl brine solution in a high-speed mixture. After gravity separation



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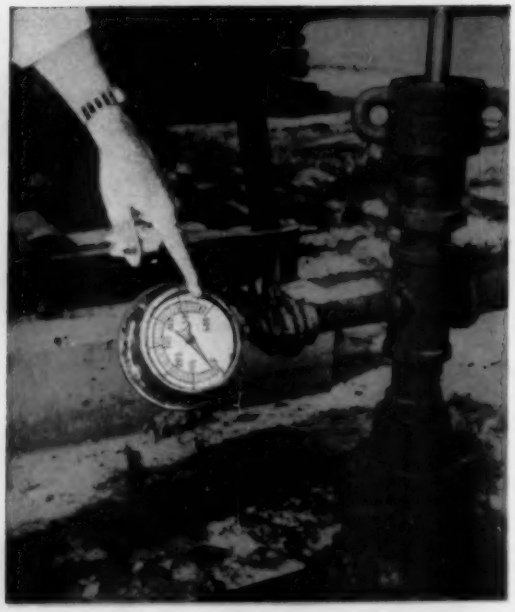

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TRETOLITE SERVICE
report

SOLVO* PARAFFIN REMOVER REDUCES FLOW LINE PRESSURE from 430 to 20 psig

When SOLVO Paraffin Remover treatment was started on a Kansas well, the flow line pressure was at 430 p.s.i.g. Within 48 hours the flow line pressure dropped to 100 p.s.i.g. and at the end of five days' SOLVO treatment, the flow line was operating at its normal pressure of 20 p.s.i.g. The table shows how SOLVO Paraffin Remover was applied.

TIME LAPSE	AMOUNT OF SOLVO USED	WHERE SOLVO WAS APPLIED	FLOW LINE PRESSURE (p.s.i.g.)
Start	5 gals. SOLVO 5 gals. Kerosine	Well Annulus	430
24 hrs.	5 gals. SOLVO	Flow Line	430
48 hrs.	2 gals. SOLVO 1 qt. Moth Balls	Flow Line	100
72 hrs.	0	—	20

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An important consideration in this case is the fact that the flow line pressure had built up to the 430 p.s.i.g. with a so-called "paraffin solvent" in use. This paraffin solvent cost the producer 20% more per gallon than SOLVO.

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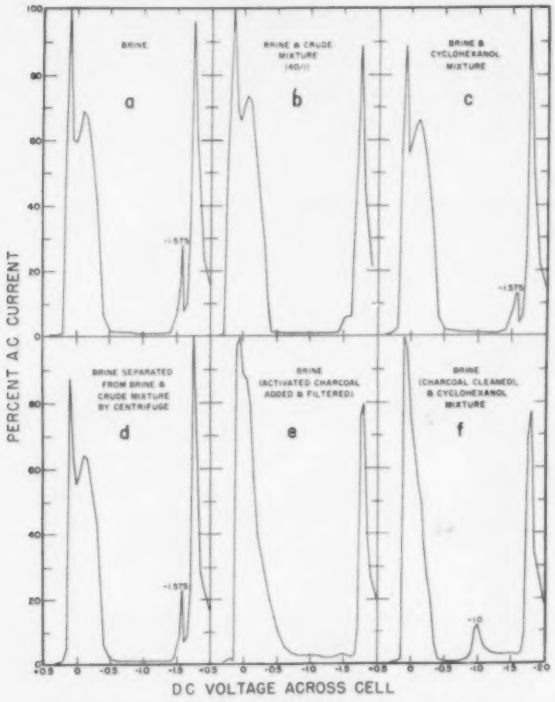


FIG. 3. **Brine from the Hawkins field** exhibits a strong surfactant peak which is suppressed when mixed with the crude oil. This field is considered to be water-wet.

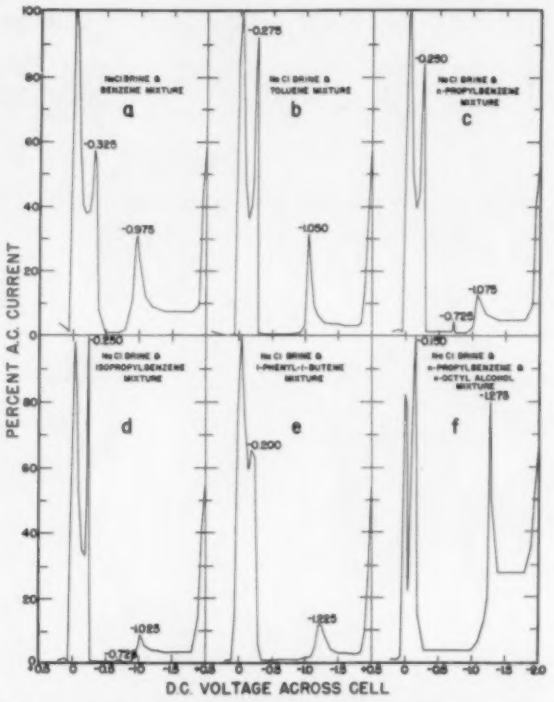


FIG. 4. **Various aromatic compounds** tested in mixture with NaCl brine show definite surfactant peaks in the tensammetric analysis.

of the excess oil, a sample is withdrawn from the lower part of the mixture and transferred to the tensammetric cell. A tensammetric profile is obtained and compared to that of the 0.1 N NaCl brine solution.

Each peak which appears in the profile of the mixture that does not exist in the profile of its brine, is tested to determine if the peak is a surfactant peak. Checks are made for the first three characteristics of surfactant peaks as the data are taken. The fourth test is made by adding a small quantity of a surfactant known to be strongly adsorbed on the mercury electrode to the oilfield brine-crude oil (hydrocarbon-brine) mixture. The tensammetric response curve of the new mixture is obtained. If the peak or peaks observed for the oilfield brine-crude oil (hydrocarbon-brine) mixture are tensammetric peaks, i.e., due to adsorption-desorption equilibria of surface active molecules at the electrode-solution interface, addition of a more strongly adsorbed surfactant will cause the peaks being tested to be suppressed and only the peaks of the surfactant will appear.

In one such test, addition of a surfactant caused the peaks of both the oilfield brine-crude oil and the hydrocarbon-brine mixtures to be suppressed. As an additional test, the crude oil was separated from the brine of the remaining part of the brine-oil mixture using a high-speed (3000 rpm) centrifuge. The tensammetric response curve of the oil-free brine was obtained. Brine separated from the oil by the centrifuging did not contain a surfactant.

The effect of concentration of oil in the brine-oil emulsion is studied carefully. If a brine-oil tensammetric peak appears, increasing the amount of oil past a low concentration (usually 2½ percent) causes a suppression of the brine-oil peak.

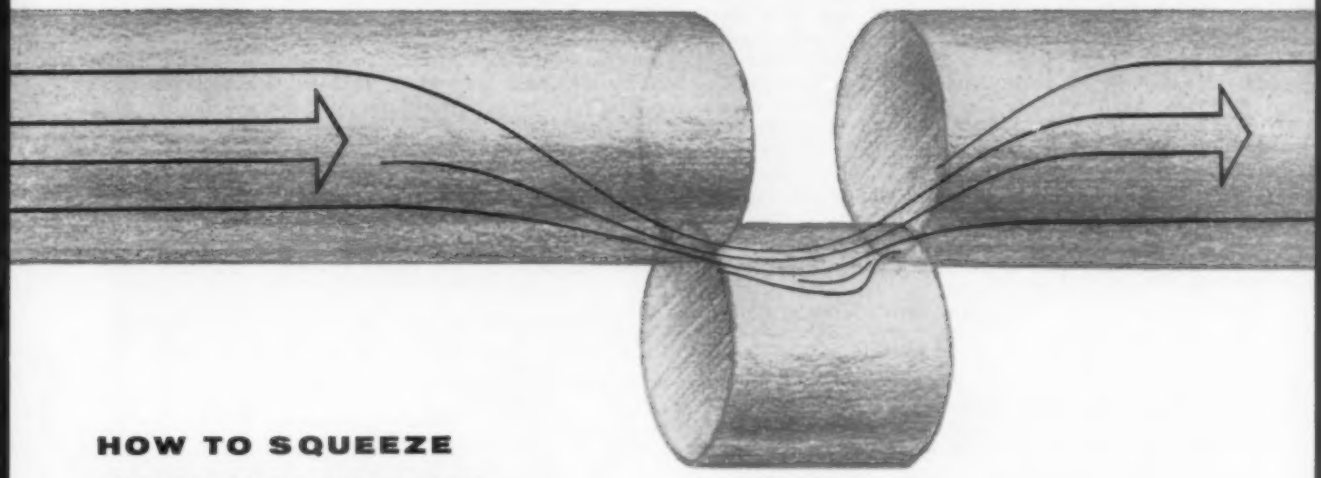
Data and Results

The Wilcox sand of the Oklahoma City field is one of the few sands generally labelled "preferentially oil-wet." Brine from this field does not contain a detectable surfactant (Fig. 1-a). The response curve of a 0.5 percent mixture of Oklahoma City crude oil in Oklahoma City brine has a peak at −0.925 volts (Fig. 1-b), which is replaced by the surfactant peak when n-octyl alcohol is added to the brine-oil mixture (Fig. 1-f). This peak exhibits all of the characteristics of a tensammetric peak. Furthermore, the peak does not appear in the response curve of the brine extracted from the brine-oil mixture (Fig. 1-d), a fact which shows that the phenomena are associated with the oil phase and are not transferred to the brine phase.

Because the surface-active phenomena are associated only with the oil phase, the smaller the size of the average droplet adsorbed on the mercury electrode, the greater the surface activity indicated by the alternating current. Increasing the concentration of the crude oil in the brine causes the droplets to coalesce and serves to reduce the alternating current measured at the adsorption-desorption peak (Fig. 1-e). It also changed the composition of the electrolyte sufficiently to shift the adsorption-desorption peak from −0.925 to −0.875 volts.

The brine produced from the East Texas field, Woodbine formation, does not contain a detectable surfactant. Results obtained in a study of the brine-oil mixtures of the East Texas field fluids were similar to those obtained with the Oklahoma City field fluids.

Four of the seven different brines produced from the Frio formation in different fields have response curves without a tensammetric peak.[1] Fresh brine samples, obtained in 1957, verified the results of earlier investigation. Fluids from all four of the fields, Dickinson (Fig. 2), East White Point, Plymouth and Midway, were studied using the same tests as applied to the fluids from the Oklahoma City and



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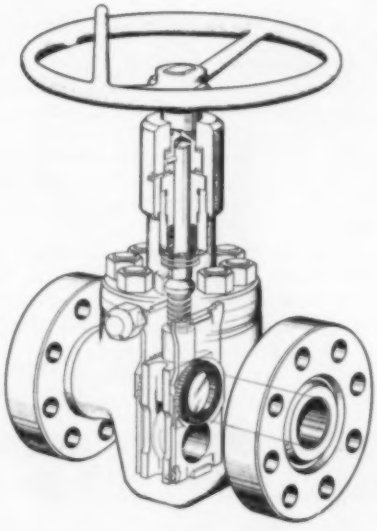

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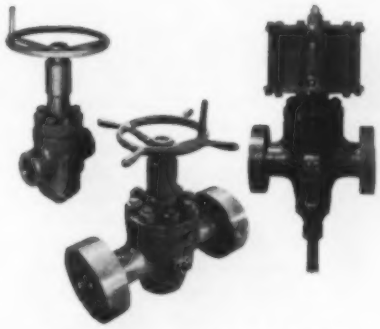

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East Texas fields. Similar results were obtained for fluids produced from the six different fields.

Studies were made of brines and oils produced from the Talco, Big Lake, Dollard and Hawkins fields. Both brine and crude from Big Lake field contained hydrogen sulfide gas in solution. After the fluids had stabilized, neither the response curve of the brine nor the brine-oil mixture had a tensammetric peak.

Fluid samples from Talco field, Paluxy formation, were also initially chemically unstable. After chemical stability had been reached neither the brine nor the brine-oil mixture had a tensammetric peak in its response curve.

Imbibition tests conducted by one of the major companies on cores from Dollard field, Canada revealed that anaerobic cores imbibed water whereas cores, after exposure to air, imbibed oil. A sample of crude oil from the Dollard field, Canada, which had been exposed to air, was tested. As the field has produced no brine, a synthetic brine, 0.1 N NaCl, was used as the supporting electrolyte. The response curve of the 0.1 N NaCl-brine-Dollard crude oil mixture differed from those of the Oklahoma City-East Texas-Frio fields group in that both the positive and negative peaks of the surfactant appeared. Both peaks were displaced by the addition of a surfactant.

A different response was obtained from mixtures of fluids produced from Hawkins field (Woodbine formation). Hawkins is considered to be a preferentially water-wet field. The response curve of Hawkins brine has a peak at –1.575 volts (Fig. 3-a). The response curve is not changed by addition to the brine of a surfactant having a lesser peak voltage, indicating that the peak is a tensammetric peak (Fig. 3-c). Efforts to remove the substance giving the peak from the filtered brine by centrifuging, flocculation with alum, flocculation with $FeSO_4$ (neutral solution), or by flocculation with NaOH (basic solution), were unsuccessful.

The peak was removed by adsorption of the surfactant material on charcoal (Fig. 3-e). The response curve of the solution obtained by adding a surfactant, cyclohexanol, to this treated brine has the cyclohexanol peak (Fig. 3-f). Cyclohexanol, in turn, was removed by adsorption on charcoal. Thus, the peak is due to a surfactant in solution in the brine. Although the surfactant is in solution in the brine, it is suppressed by the Hawkins crude oil when oil is mixed with the brine (Fig 3-b).

As a further check on the uniqueness of the response of the fluids from the Oklahoma City-East Texas-Frio formation fields, a series of tests were run using several samples of kerosine, purchased at different times from different companies. They were tested in the same manner as the crude oils were tested. As none of the samples gave a tensammetric peak, the kerosine did not contain a surfactant and did not behave as a surfactant when in a brine-kerosine mixture.

The supporting electrolyte used to obtain the response curves of the pure hydrocarbons was a 0.1 N NaCl solution. Response curves of 0.1 N NaCl brine-n-heptane, -n-octane, -n-nonane, and -n-decane mixtures are very similar to the response curve of the supporting electrolyte alone.

None of the four olefins examined showed tensammetric characteristics.

The response curve of cyclopentane shows a strong tensammetric peak at –0.450. A possible companion peak at –0.7 was not present. Addition of a surfactant, n-octyl alcohol, causes replacement of the peak by n-octyl alcohol peaks, further evidence that the cyclopentane peak is tensammetric in nature.

All of the aromatic compounds examined showed tensammetric characteristics. Benzene tensammetric peaks (Fig. 4-a) are displaced by n-octyl alcohol peaks. Both toluene and 1-phenyl-1-butene (Fig. 4-b, 4-c) exhibit tensammetric peaks.

Response curves of n-propylbenzene and isopropylbenzene (cumene) are distinctly different from those obtained for other aromatic compounds in that a third small "peak" appears (Fig. 4-c, 4-d). All three "peaks" are displaced by n-octyl alcohol peaks.

Acknowledgment

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5. Hacobian, S., "On the Mechanism of the Polargraphic Reduction of Oxygen," *Aust. Jour. Chem.* (1953) 5, 186.

★ ★ ★

Addendum . . .

Immediately before the conclusion of the article entitled "Continuous Flow Gas Lift Design," by Kermit E. Brown and Carlos R. Canalizo, which appeared in the January issue, p. B-26, the following should appear:

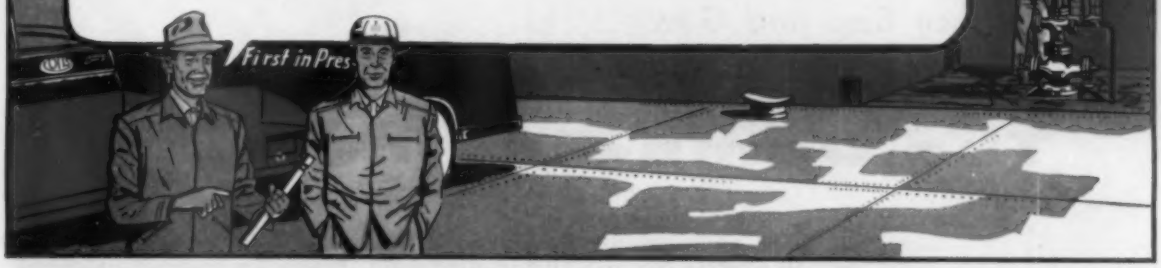
"A summary of these results is as follows:

Water-Oil Ratios	Depths of Points of Injection		
	Detailed (ft)	Simplified (ft)	Difference (ft)
2	2500	2920	420
4	2925	3125	200
6	3125	3285	160
7	3250	3355	105

"It is immediately evident that as the percent of water production increases, the results obtained by the simplified method approach those calculated by the detailed procedure. An installation designed by the simplified method locates the point of injection lower than calculated by the detailed methods, providing a safe design. Extreme accuracy in well information must be available to assure correct calculations by the detailed procedure.

"As a matter of interest, Fig. 8 shows that for water-oil ratios up to 1, the well would flow naturally."

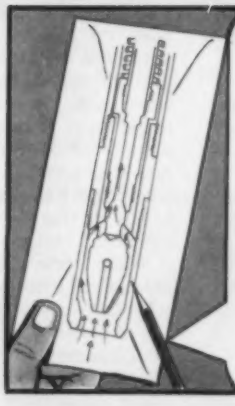
One of these **OTIS TUBING SAFETY VALVES** shut in this well when it threatened to blow wild, and **SAVED US THOUSANDS OF DOLLARS** in lost production and a possible serious fire.



The well was producing 2½ M.M.C.F.D. of gas with 89 B.D. of sand-laden oil when a leak developed at the flange of the master valve. At the time, the flowing pressure was 3,100 P.S.I., so it didn't take long for the gas and sand to cut out a sizable hole. As soon as the pressure differential exceeded the setting of the Otis Storm Choke, it automatically snapped shut.

This morning we pumped down through the safety valve and killed the well with water—then broke out the master valve to repair the leaky connection. Now we're resetting the tree. We called out Otis to pull, check, and redress the safety valve before we put the well back on production. The valve's probably O.K., but it's been down there 10 months and under our safety program we pull all of our safety valves periodically for inspection anyway.

We just pulled the Storm Choke from this well and, although it has had heavily sand-laden fluid produced through it for the past 10 months, the bean is hardly flow-cut. The valve is one of our Type F valves, which we originally set for this customer. We've replaced the bean, redressed the valve, checked the setting, and are in the process of rerunning it. Our Type F valve is a spring-loaded valve that snaps closed when pressure, created by an increased flow through the valve, exceeds the compression setting of the valve spring.



In the opened position, flow through the valve follows a single, straight course. The valve is designed so that the sealing surfaces of the valve, and the valve seat, are out of the direct line of flow to minimize possible cutting action of the fluid. Although our tubing safety valves are pressure-differentially-operated, they will not close prematurely due to surging heads—and they can be adjusted to operate dependably within a very close range.

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The Damn-Engineers

Reporting on the changing scene, here is a tongue-in-cheek account of the graduation of the slip-stick-bearing "damn-engineer" into the school of experience

Mary Thompson Garner, *Tyler, Texas*

THE OTHER DAY I overheard someone use the expression "damn engineer" and I was quite shocked to realize it was being used as two words and with the usual connotation for the first. Having been introduced to the term on a ham-and-eggs basis during my early oilfield days, I was plumb provoked to have someone do away with the hyphen and use the words in their literal sense.

However, with all the changes being wrought these days in the oil industry, I guess such old endearing terminology will get a mouth-lifting, too. And as the rapid changes take place on the petroleum scene, I find myself nostalgically thinking of "the good old days." So many things that were a part of my work in an oilfield office only 10 years ago have already been overridden by the wheels of progress.

White-Frame Campsite

Time was, if you were driving along the highway between towns and suddenly came upon what appeared to be one whole block cut out of a residential section and set down in the wide-open spaces, chances were it was the field office and campsite of some oil company. There were usually at least two dead-end paved streets with identical white frame houses lining each side. There was one larger, rectangular, white frame building on another street apart from the residences. This was the office building, with nicely kept, grass-covered grounds in front decorated with a flag pole and an asphalted area in the back decorated with pipe racks. A lot of money had been spent to provide shade trees, pretty lawns, and sidewalks just like in town.

But this was not in town; it was from 10 to 40 miles from the nearest one. And the first field office in which I worked was at least a mile from a highway so we didn't have many traveling sightseers.

These camps were literally right in the middle of the oilfields. The people who drilled the wells, produced the oil, made the reports, and supervised the operations lived in the houses and some of them worked in the office. Only recently have the oil companies begun to get away from this practice of putting the office in the field. The trend now is to establish headquarters in the nearest town so the people can become a part of that town and its activities. I'm glad I beat the trend.

When I first went to work in such a field office, I believed I was fairly well acquainted with the oil industry. I had previously worked for two other oil companies, in the big-city home office of one and in the big-town refining department of another. I also had a smattering of knowledge about geological formations and the like left over from college days so I wasn't afraid to tackle the subsurface terms I knew would be involved with drilling and production work.

Field Office: Wall-to-Wall Linoleum

Of course, I realized the actual physical aspects of the job would be different. Before, I'd worked in tall office buildings with elevators, carpeted floors, receptionists, men in coats and ties, and women in high heels. Here I would be working in the country in an office building designed along shotgun architectural lines, with linoleumed floors, and temperamental, crank-style telephones that promptly went dead every time the wind jostled the lines. Inside, the office building was laid-off like the campsite streets, with identical box-shaped offices on both sides of a central building-length hall. Most of the men wore dirty boots and khakis or ex-service regalia. Even if the top brass did wear its accepted suit of armor, coats and ties were relegated to a corner wall rack — unless more important top brass was expected. And since I was the only female in the organization, I had no standard attire to maintain. The men wouldn't have cared — or noticed — if I'd gone barefoot.

Except for these few variations, I had presumed my work would be pretty much like it had been before. And I soon found out just how presumptuous I had been. I might have known the language of the oil industry, but I did not know oilfield lingo. I discovered that staying on speaking terms where items of equipment and operational processes were concerned was a never-ending job in a field office.

Occupational titles, though, I found should be got straight and kept straight. Boss of the whole shebang was the superintendent, and he had an assistant. They were aided and abetted by the services of pencil-pushers and key-punchers who made up what was known as the clerical department. The farm bosses were in charge of the gang-pushers and pumpers. The gangpushers were in charge of the roustabouts. There was a toolpusher who supervised the drilling crews. (Note: Among the many recent changes made in the oil business has been the re-vamping of job

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classifications. Nearly all of these occupations have now been given more high-falutin' titles.)

The Damn-Engineers

And then there were the damn-engineers. One word.

Now the damn-engineers were not to be confused with various skilled laborers who ran assorted engines and were therefore termed engineers. They got their hands dirty operating those engines, so they were called engineers and there was no handle attached.

Damn-engineers, on the other hand, were all college graduates. I had to learn to dispatch with all engineering prefixes such as petroleum, mechanical, chemical, civil, aeronautical, and the like. In the oilfield there was no discrimination — they were all lumped under one general job title classification: damn-engineers.

Now you can tell by the elemental quality of most true oilfield lingo that originally the oilfields were primarily operated by men who had learned things the hard way. To them the slide-rule boys were johnny-come-lately's to the oil business. They objected to being told how to do something from a scientific viewpoint that they had been doing from a seat-of-the-pants viewpoint for years. These practical men resented this intrusion, for the actual oilfields had long been their province. The fields housed the schools of experience from which they graduated in the days when college educations were the exception rather than the expected. They firmly believed the damn-engineers should stay in the fancy offices in the cities to make their fancy slip-stick calculations. Why, most of the newcomers didn't even use the spitoons by their desks! The battle of experience versus education was begun, and it showed promise of being as drawn out as the one between the North and the South.

Until the last few years field offices were usually staffed with practical men in most of the supervisory positions, with the damn-engineers as a line organization to counsel and recommend. Times have changed though, and degree-holders are infiltrating the supervisory ranks in field offices more and more. Experienced practical men and educated professionals are being used in a salt-and-pepper supervisory mixture. But many of the field men feel there is a decided tendency to overseason with damn-engineers.

However, I have a feeling the conflict will eventually be resolved by application of the theory "if you can't whip 'em, jine 'em." For almost without exception the practical men are packing their sons off to college to make damn-engineers. ★ ★ ★

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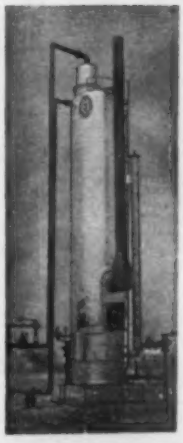

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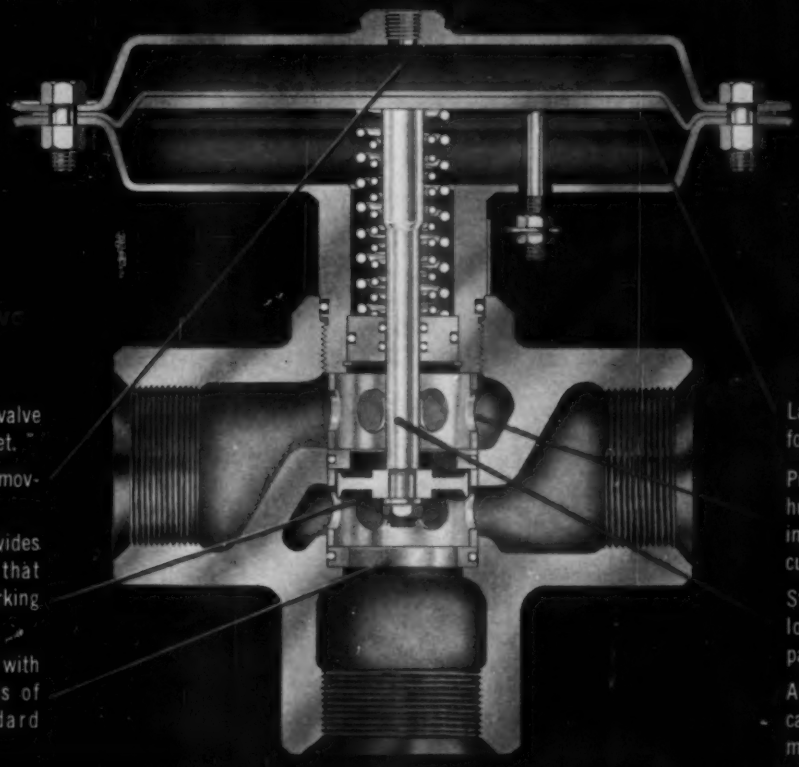

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Rapid Evaluation of Corrosion Inhibitors

This 48-hour test will give you a basis for the quantitative comparison of the effectiveness of corrosion inhibitors against any water-soluble corrosion agent

Paul A. Little and Marvin Gambill
United Chemical Corporation of New Mexico, Hobbs, New Mexico

THE PETROLEUM INDUSTRY spends large sums of money annually on corrosion inhibitors in an effort to prolong the usefulness of metallic equipment. The methods employed to determine the effectiveness of corrosion inhibitors fall, usually, in the catagory of "field trials." They are time-consuming, expensive, and usually fail to give the precise quantitative data obtainable from carefully designed laboratory tests.

An inexpensive 48-hour test method has been developed which permits quantitative comparisons of the effectiveness of different corrosion inhibitors against whatever water-soluble agent of corrosion the operator may care to select. Studies of gases such as carbon dioxide and hydrogen sulfide have been made by bubbling the gases through distilled water. Design of the test is based on procedures widely accepted for the evaluation of biologicals[1,2,3,4] where the significance of results is inherent in their reproducibility. Main features of the test are: (a) use of suitable controls, including a reference inhibitor, (b) use of three or more titration levels of each inhibitor, (c) elimination of all variables but one, and (d) presentation of results in a useful form.

Selection of Corrosion Agent

A reproducible corrosion agent of known composition is indispensable for the purpose of standardizing the test method. In our laboratory, a solution of four percent sodium chloride in distilled water was found to give a corrosion rate of 0.26 ± 0.02 milligrams per hour when tested against standard type mild steel corrosion coupons. Total loss in weight of the coupons for the 48-hour test interval was 12.48 ± 0.96 mg. This amount of weight loss was selected as the corrosion-objective for control coupons for the following reasons. Laboratory experiments showed that much greater weight losses decrease the sensitivity of the test by reducing chances of detecting activity of some inhibitors at levels commonly recommended for field use. Smaller weight losses in controls decrease the sensitivity of the test by reducing chances of discriminating between inhibitors whose activity is not dramatically different.

Most field samples of water tested have approximated the corrosion-objective in the 48-hour test interval. In working with corrosion agents having lower corrosion rates, the test interval should be extended until total loss in weight of control coupons is in the desired range. Similarly, the test interval may be shortened to accommodate corrosion agents having much faster corrosion rates.

Design of the Test

The significant intervals at which a corrosion inhibitor should be tested are dictated by the nature of the titration curve. While corrosion inhibitors are commonly recommended for field use in the range of 10, 20, and 30 ppm and may be demonstrated to have activity at these levels, we have found it more informative to test at intervals of 1, 100, and 10,000 ppm. When a more detailed study of the titration curve is desired, we test at 1, 10, 100, 1000, and 10,000 ppm. A typical titration curve obtained by this means is shown in Fig. 1.

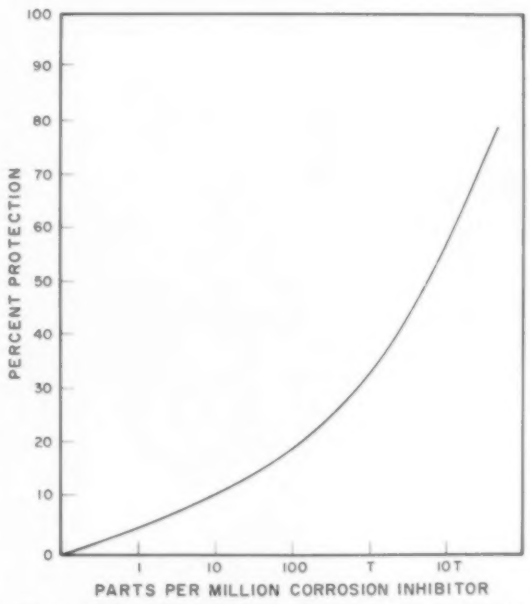

FIG. 1. **Typical titration curve** shows the percent protection against corrosion resulting from various concentrations of corrosion inhibitor.

In carrying out the test, a homogeneous solution of corrosion agent is distributed in 100-ml amounts into separate containers identified by serial numbers. Dilutions of corrosion inhibitors are prepared as desired. Then, serially-numbered, cleaned, and weighed coupons are placed separately in the bottles in positions enabling the operator to observe the corrosion process as it occurs on the upper surface of each. Visual observations should confirm and extend the information obtainable from weight loss determinations. Accurate records of the time each test is started and terminated are used for determining corrosion rate for the control coupons. This is one of the internal criteria used for determining the reliability of each test; corrosion rate should remain constant for a given corrosion agent. Table 1 shows a typical test record.

Calculation of Percent Protection

Much otherwise useful information becomes hidden when the English system of empirical units, such as "mils per year," is employed. We have

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TABLE 1. Typical Test Record.

Corrosion agent: 4% NaCl — 100-ml volumes
Time Started: Tuesday, 11 a.m.
Time Terminated: Thursday, 12 a.m.; 49 hours — Corrosion rate: 0.28 Mg/hr

Material Tested	Dilution	Weight of Coupons-gm		Weight Loss-gm	Percent Protection
		Start	Final		
Control		11.0870	11.0755	11.5	Control
Sample 101	1-100	11.1210	11.1134	7.6	33.9%
Sample 101	1-10T	11.0947	11.0849	9.8	14.7%
Sample 101	1-M	11.6626	11.6521	10.5	8.6%
Sample 102	1-100	11.4190	11.4176	1.4	87.8%
Sample 102	1-10T	11.2575	11.2476	9.9	13.9%
Sample 102	1-M	11.2348	11.2251	9.7	16.3%
Sample 103	1-100	11.0349	11.0287	6.2	46.0%
Sample 103	1-10T	11.2940	11.2839	10.1	12.1%
Sample 103	1-M	11.2716	11.2611	10.5	8.6%

TABLE 2. Relative Effectiveness of Different Corrosion Inhibitors.

Corrosion Inhibitor	Percent Protection at			Relative Effectiveness
	1 ppm	100 ppm	10,000 ppm	
Product A	7.8	11.5	77.8	7X
Product B	4.7	20.3	69.9	7X
Product C	7.1	12.1	26.3	2X
Product D	3.3	11.0	10.3	1X
Product E	5.7	7.1	39.4	4X

Averaged results of 3 retests. Corrosion agent: 4% NaCl.

chosen "percent protection" as the most desirable method for expressing results because it incorporates the degree of corrosion obtained in the control as a reference point and provides a positive rather than a negative picture of happenings. Percent protection is calculated by subtracting weight loss of the treated coupons from weight loss of the control coupon, then dividing the difference by weight loss of the control and multiplying by 100.

Example:

(A) weight loss of control

(B) weight loss of treated coupon

(C) difference

$\frac{C}{A}$ times 100 = Percent Protection

When the treated coupon shows no weight loss, the degree of protection is 100 percent; conversely, when weight loss of the treated coupon is the same as the control, protection is 0 percent.

Interpretation of Results

A single test shows the trend of the activity curve characteristic of inhibitors tested. Discrepancies in data obtained for various titration points may be detected by inspection, and the most probable value predicted by smoothing the curve. Errors in weighing of coupons and in making serial dilutions of inhibitors are, thus, made more self-evident when a three-point titration is used than when an inhibitor is tested at a single level. Some operators may want to make duplicate or triplicate tests to rule out variations. We like to achieve this objective by repeating the titrations at different times. Table 2 shows results of accumulated tests comparing the effectiveness of various corrosion inhibitors. It will be noted that the concentration of 10,000 ppm gives the best spread of data for determining relative effectiveness of different inhibitors. ★ ★ ★

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RUNNING TOUR with MEN in the INDUSTRY

Harry W. Bass Jr., president of Harry Bass Oil Company, announces that **W. P. Dockery** has joined their organization as production manager for their Canadian operations. Dockery was associated with Imperial Oil Limited in Regina, Edmonton, Camrose and Redwater for a total of 5 years. During the past two years, he was with Great Plains Development Company of Canada, Ltd. in Calgary.

W. P. Dockery

Dr. F. G. Miller

Dr. Frank G. Miller, executive head, Department of Petroleum Engineering, Stanford University, is on leave during the current academic year. For the past several months he has been in South America making special reservoir studies for Mobil Oil Company de Venezuela. He plans to return to the United States early in 1960.

Ken H. Ault has joined Trunkline Gas Company, Houston, Texas, as district production engineer in the Lafayette, La., office. He formerly was associated with Forest Oil Company.

O. G. Simpson, division production superintendent for Sinclair Oil & Gas Company at Midland, Texas, has been appointed assistant division manager at Midland, **William H. Morris,** president, announced.

Simpson succeeds **R. L. Elston,** who was elected a vice president and appointed Midland division manager November 1 when **G. D. Almen Jr.** was promoted and transferred to offices of Sinclair Oil Corporation in New York City.

V. L. Frost, formerly exploration manager of the Oasis Oil Company of Libya, a wholly owned subsidiary of the Ohio Oil Company, has been assigned to the parent company's staff of the manager of exploration for foreign production. He will be headquartered at Ohio Oil's general office, Findlay, Ohio. **B. B. Colley,** formerly exploration manager of the Continental Oil Company's Oklahoma City regional division, has been assigned to Oasis on a loan basis to succeed Frost.

Joe B. McShane has joined **B. Oliver Wood,** consulting petroleum engineer, to form Wood & McShane, petroleum consultants, in Monahans, Texas. The new organization specializes in the engineering, operations, and management of secondary recovery projects in West Texas and Southeastern New Mexico.

Personnel moves in connection with the recent changes in Atlantic Refining Company's domestic crude oil production department's regional division have been announced. Appointments for the newly created Mid-Continent Region include: **H. C. Harris Jr.,** presently manager of the Dallas Eastern region, will be the regional manager. **Charles W. Alcock,** Oklahome-Kansas exploration manager, will continue in that capacity for the new region. **Gordon T. Lepley Jr.,** operations manager for Dallas eastern, will hold the same job for the new region. **Jesse P. Johnson,** Oklahoma-Kansas operations manager, will serve the new region as regional production superintendent. **J. H. Sullivan,** Dallas Eastern petroleum engineer, will continue in that job with the new region. **James E. Lloyd,** Dallas Eastern drilling manager, will be drilling superintendent for the new region.

Dr. Lawrence W. Jordan Jr. has joined the oil recovery division at the La Habra Laboratory of California Research Corporation as a research engineer. Jordan recently completed work for a Ph.D. in chemical engineering at Ohio State University.

Dr. Angelos V. Patsis has accepted a position as research chemist in the same division at the laboratory. He recently received his degree in physical chemistry from Western Reserve University.

George R. Brown has been appointed assistant manager of the Texaco Exploration Company, a wholly owned subsidiary of Texaco Inc. He succeeds **Roy Whisenhunt,** who has been transferred to Midland, Texas, to become assistant manager of the Midland division of the domestic producing department of Texaco Inc.

Homer B. Rainbolt has been promoted to chief landman, a new position, in the exploration division of the domestic producing department of Texaco Inc. His headquarters will be in Houston and the change already is effective.

N. M. Faulkner Jr. has been promoted to division landman of the Dallas division, domestic producing department of Texaco Inc.

Faulkner, who has been assistant division landman, succeeds Rainbolt.

Jas. D. Hughes and Associates, specialists in sales consulting and market research, have opened offices in Houston, Texas. The new organization, **Jas. D. Hughes,** stated, will utilize the services of seasoned executives in the fields of sales, management and engineering. Hughes headed the sales activities of Lane-Wells Company for more than nineteen years. He recently resigned as a vice president of that firm to start his own company.

F. E. McPhillips was appointed to the newly created post of assistant general manager of the production department by Richfield Oil Corporation. McPhillips will be responsible for all phases of the department's operations—including activities of the exploration, operating and land and lease divisions. He will report to **W. J. Travers,** vice president in charge of production. **E. M. Benson Jr.,** has assumed McPhillips' former position as manager of the land and lease division. Joint and foreign operations activities formerly supervised by Benson will become part of the land and lease division.

Fred Stephens has acquired sole ownership of the firm Cable & Stephens, Petroleum Engineers, Wichita Falls, Texas, having purchased the partnership interest of **J. H. Cable.** The firm name is Stephens Engineering. Cable will be associated with Stephens Engineering as a consulting engineer.

H. H. Neel

Robert Dyk

Tidewater Oil Company has formed a new operating division to contain its foreign exploration and production activities. The new division will direct Tidewater's exploration and production work in all foreign countries with the exception of the Iranian Consortium in Iran, and operations in Saskatchewan, Canada.

General manager of the new division is **Henry H. Neel,** who headed a foreign exploration and production department before the formation of the company division. Neel has named **Robert Dyk** division exploration manager and **John P. McCabe** to the post of division production manager. Dyk was formerly chief geophysicist for Tidewater and McCabe has been serving as assistant to Tidewater's home office production manager. A full management staff is planned for the division, and other executive appointments are expected to be announced in the near future.

George H. Truran was named to the newly created position of division production superintendent of the Flying A firm's western division.

Truran holds a degree in mechanical engineering from Purdue University.

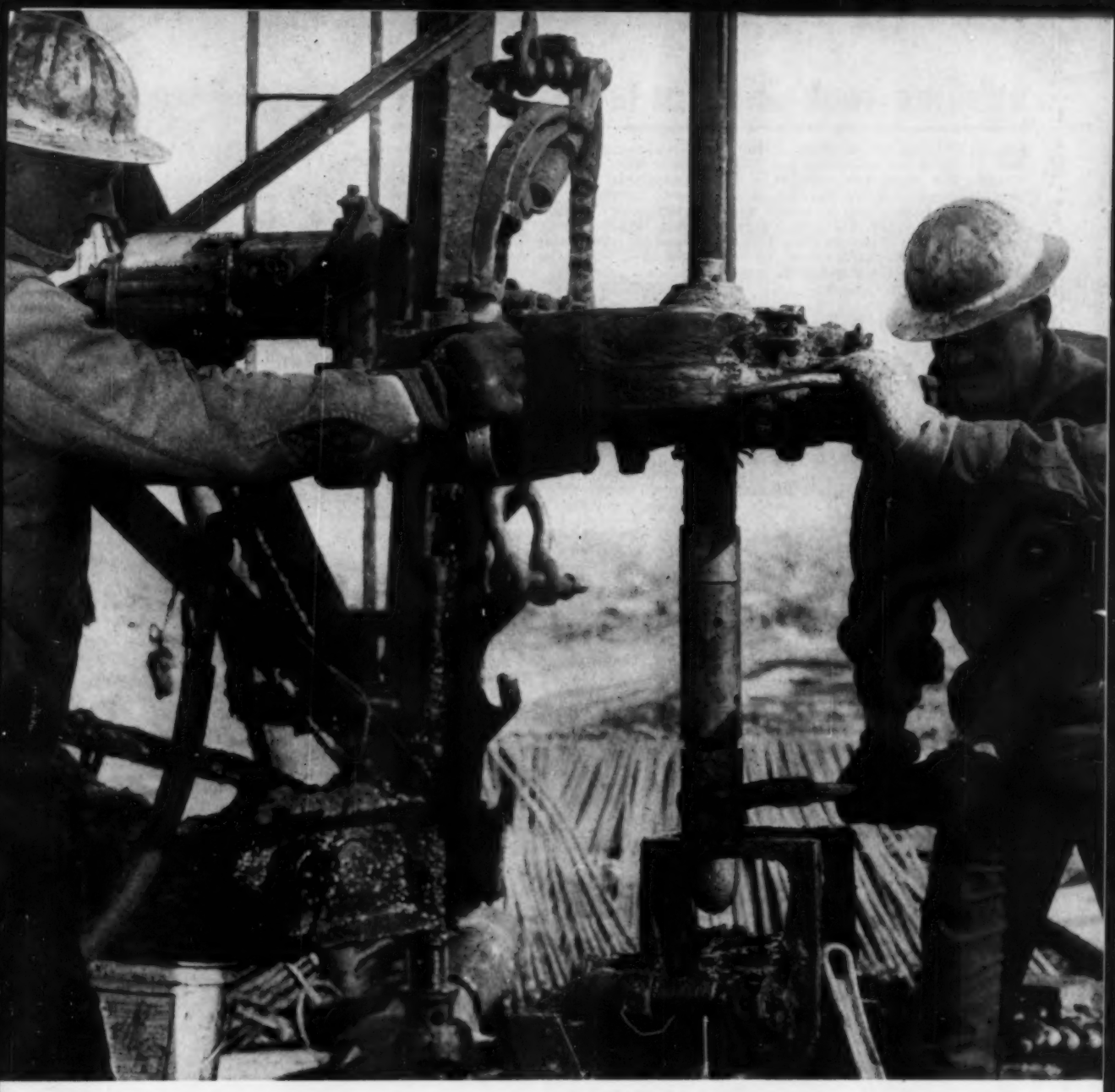
J. P. McCabe

Ernest Allen Jr.

Ernest Allen Jr. has been elected vice president and director of General Technical Services Corporation, Panama, R.P., and will headquarter in Paris, France. Other officers of the company, which was formed last year, are **D. R. McCord,** president; **L. L. Shackelford Jr.,** secretary-treasurer; **J. Hugh Faulk,** chief engineer; and **C. D. Carter,** senior production engineer.

Delhi-Taylor Oil Corporation has announced two new appointments in its production division. **O. W. Crisman** has been named manager of Delhi's McAllen, Texas, production district; and **W. S. McCready** has assumed the position of production supervisor in the Dallas headquarters.

Thomas W. Brinkley, chief reservoir engineer for Sunray Mid-Continent Oil Company, has been appointed international chairman of the American Institute of Mining Engineer's production review committee. He previously served as chairman of the Oklahoma group which covered a five-state area.



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Abrasijet* is a new Dowell-developed formation cleaning and perforating service. It uses high-velocity streams of fluid and abrasive particles, usually sand (pumped through small jet orifices in the tool pictured above) to perforate casing or cut through well bore damage. Water, oil, acid and mud have been used as the sand-carrying fluid.

Reports from field after field show that Abrasijet gives better results than more conventional treatments in many instances. These same reports also show that Abrasijet has been successful in cases where all other treatments failed. Here are a few examples:

IN SOUTH TEXAS. Abrasijet was used to re-perforate a Wilcox well and penetrate beyond gyp deposited near the well bore. Production had dropped to 10 bopd on gas lift. Five sets of two perforations per level were jetted using Dowell inhibited acid and sand. *Production rose to 96 bopd with 880 psi flowing pressure.*

IN NORTHWESTERN NEW MEXICO. *Abrasijet was used to complete a 260 bopd flowing well in an area surrounded by dry holes.* Completion was into a 22-foot section of the Dakota. Abrasijet was employed to make 48 perforations in twelve settings of a four-jet tool. Well was also fractured in the basic eight-hour pump-rental time.

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"ACID GUIDE"*

This new companion to the "Frac Guide"* is used by Dowell for *better* engineering of acid treatments. Results have been greater production increases, lower treatment costs, or both. Probable results of acid treatments can be predicted, and the most promising treatment selected for a given well.

CORROSION INHIBITOR SQUEEZE

This Dowell-developed technique for inhibiting corrosion in oil wells has given excellent long-term protection with minimum cost of application. Second and later applications of Corban* inhibitor by "squeezing" it into the producing formation have been even more efficient than the first.

FOAMING AGENT FOR WATER REMOVAL

This new Dowell addition agent can be added to water used in fracturing to induce foaming and reduce swabbing time. It is also used to facilitate air or gas drilling through low-production water zones. For air drilling, it minimizes "balling" of cuttings and creates a foam for easier water removal.

IN SASKATCHEWAN, CANADA. *A well was successfully perforated with Abrasijet after two attempts at explosive perforating had failed.* 4½-inch casing had been cemented through the Mississippian pay from 2318 to 2323 feet. Four perforations were made followed by a frac job. *One month later production was averaging 70 to 80 bopd in a field where most wells average only 50 to 60 bopd.*

IN CENTRAL KANSAS. *A well that produced only water on initial completion was recompleted successfully with Abrasijet.* A radioactive survey showed a channel from initial perforations at about 3318 feet to bottom of casing at 3405 feet. Well was squeezed with cement to shut off water. Abrasijet was used to reperforate without shattering cement. New perforations were from 3323 to 3329 feet. *After acidizing, well tested 6.5 boph with only a trace of water.*

The chances are good that you can increase your profits with Abrasijet. For prompt service or detailed information on Abrasijet, *dial Dowell.* There are 150 offices and stations in the United States, Canada, Argentina and Venezuela. Dowell, Tulsa 1, Oklahoma.

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SUPPLIERS' PARADE

Deutsche Dow Chemie GMBH. Formation of a new company, Deutsche Dow Chemie GMBH, with corporate headquarters in Dusseldorf, Germany, is announced by C. B. Branch, president of Dow Chemical International Limited S.A.

The wholly-owned German subsidiary will provide German operators of oil and gas wells with acidizing, fracturing and cementing services.

Locations for providing these services have not yet been selected, but it is expected that the principal office will be in the Hanover area with some service points to be established later in that general area.

The initial paid-in capital of the new corporation is 5 million DM marks ($1.25 million).

Western Company. A new Western Company service district to serve the Anadarko Basin of Northwest Oklahoma and South Central Kansas has begun operation at Woodward, Oklahoma.

Julius Carver, sales engineer at Western's Liberal, Kansas, district, assumed duties as district manager at the new station, which was constructed on the Shattuck highway west of Woodward.

Western will provide nuclear logging, perforating, fracturing and acidizing to a large area of the Basin, according to C. E. Wooldridge, Oklahoma City division manager. Woodward, Beaver, Harper, Woods, Major, Ellis, and Roger Mills counties of Oklahoma and several counties of Kansas will be included in the new district.

Woodward is the second new district in a year for Western in its Oklahoma City division. Early in 1959 a district was established at Seminole.

Western is equipping the Woodward district with its newest well servicing equipment, including Fracmaster 600 horsepower fracturing units, Acidmaster acidizing units, and the combination logging-perforating units designated Type 10 by the company.

Milwhite Mud Sales Company. Mr. H. R. Wells was recently elected executive vice president of production and properties for Milwhite Mud Sales Company, Houston, Texas. Mr. Wells is also a Director of Milwhite.

Some of the other recent positions held by Mr. Wells are assistant to chief engineer of Mississippi River Fuel Corporation (parent company of Milwhite Mud Sales Company), vice president of Mobar Corporation (formerly production division of Milwhite Mud Sales Company), and vice president of Milwhite.

Mr. Wells attended Washington University College in St. Louis, Missouri and his vocational background was in civil engineering.

Dresser-Ideco Company. J. B. O'Connor, president of Dresser Industries, Inc., manufacturer of petroleum equipment and industrial machinery, announces two changes in the executive staff of Dresser-Ideco Company of Columbus, Ohio. John L. Pausch has been raised to the newly-created position of Chairman and Henry Knippenberg is appointed president and general manager of the firm.

The Dresser-Ideco Company is a manufacturer of steel structures and buildings.

Mr. Knippenberg, the new president and general manager, joined Dresser Industries in 1956. Until August of last year he was manager of product line development for Dresser Manufacturing Division of Bradford, Pennsylvania. In August, 1959 he was transferred to the Dresser-Ideco Company as assistant to the president.

Mr. Pausch has been President and General Manager of the Dresser-Ideco Company since 1954. In his new post as chairman, Mr. Pausch will continue to make his offices at Dresser-Ideco executive headquarters in Columbus.

Mr. Knippenberg is a graduate of the Massachusetts Institute of Technology. Before joining Dresser Industries in 1956, he had been associated at various times with Booz, Allen, & Hamilton in Chicago, with Convair in San Diego and with Goss Printing Press Company and Crane Packing Company, both of Chicago.

Grove Valve and Regulator Company. Grove Valve and Regulator Company, Oakland, California, has named Gil A. Lastrapes, Jr. as production valve salesman representative in the New Orleans area.

Mr. Lastrapes, with broad field experience, has during the past twelve years been associated with Rector Well Equipment Co., Orbit Valve Company, and Oil Center Tool Co., all in the Gulf Coast area.

In his new capacity, Mr. Lastrapes will serve Grove customers in the Louisiana Gulf Coast region. He will be headquartered in new offices at 100 Peters Road, Harvey, Louisiana.

Black, Sivalls & Bryson, Inc. J. E. (Ed) Byers, Tulsa district sales manager of Black, Sivalls & Bryson, Inc's., oilfield equipment division, has been appointed regional sales manager of BS&B's Gulf and Pacific regions, according to division manager Paul Bartley.

The new regional sales manager will direct activities of the Alice, Houston, Los Angeles and New Orleans oilfield sales districts.

Byers has been with the company since graduating from the University of Oklahoma, where he earned a bachelor of science degree in natural gas engineering in 1936. His BS&B employment was interrupted for four years during World War II when he served as an Army lieutenant.

After his Army discharge in 1946, Byers returned to the company as a sales engineer in Tulsa. He was promoted to manager of the Tulsa sales district in 1952.

Gardner-Denver Company. Broadening of the financial departments of Gardner-Denver Company and election of a president of a subsidiary were voted by the board of directors at its regular quarterly meeting.

A. G. Lindquist, who has been vice president and treasurer since 1954, was elected financial vice president and secretary.

Robert H. Mevstre was elected treasurer of Gardner-Denver, reporting to the financial vice president.

Also reporting to the financial vice-president will be William Miller, controller.

Kenneth J. McDaniel, who has been secretary, was named president of one of the company's South American subsidiaries, Gardner-Denver do Brazil, S.A.

Halliburton Oil Well Cementing Company. Sales contact offices staffed by graduate engineers thoroughly experienced in Halliburton services are being opened in Dallas and Houston by Halliburton Oil Well Cementing Co., according to an announcement by Ed Trapp, sales manager.

Heading the Houston office is Schley Babin, transferred from Tulsa. He graduated from the University of Tulsa in 1949 with a BS degree in geophysics and petroleum engineering.

Bill Taylor opens the Dallas office after completing an assignment at Farmington, New Mexico, as district engineer. He obtained a BS degree in mechanical and petroleum engineering from the University of New Mexico in 1954. Taylor, a recognized authority on hydraulic fracturing, was first employed by the company in 1946 and has had field experience in Louisiana, Texas and New Mexico.

Replacing Babin at Tulsa is Ken Manes, formerly district engineer for Halliburton at Seminole, Oklahoma. He was first employed by Halliburton in 1948 and has been a cementer, tester, special tools operator and engineer in the Pacific and Mid-Continent areas. He obtained his B.S. degree in petroleum engineering from the University of Oklahoma. The Tulsa office is headed by J. M. "Skip" Montgomery, sales engineer and a veteran with Halliburton services since 1940.

Another personnel change announced by Halliburton was promotion of Pat Broussard from assistant division engineer to division engineer at Houston. Broussard graduated from Southwestern Louisiana Institute in 1948 with a B.S. degree in chemical engineering. Since then he has held varied operating and engineering assignments for Halliburton in the Texas and Louisiana Gulf Coast.

Welex, Inc. In a series of top-level organizational changes, R. O. Shaffer, president of Welex, Inc., wireline service company, recently announced the promotion of two veteran employees to vice president.

Affected by the changes:

Larry Drake, Oklahoma division manager, was promoted to vice president in charge of the Oklahoma Division. He will remain in Tulsa.

B. A. Redwine, former Gulf Coast sales manager, was named vice president in charge of Texas and Louisiana Gulf Coast sales and operations at Houston.

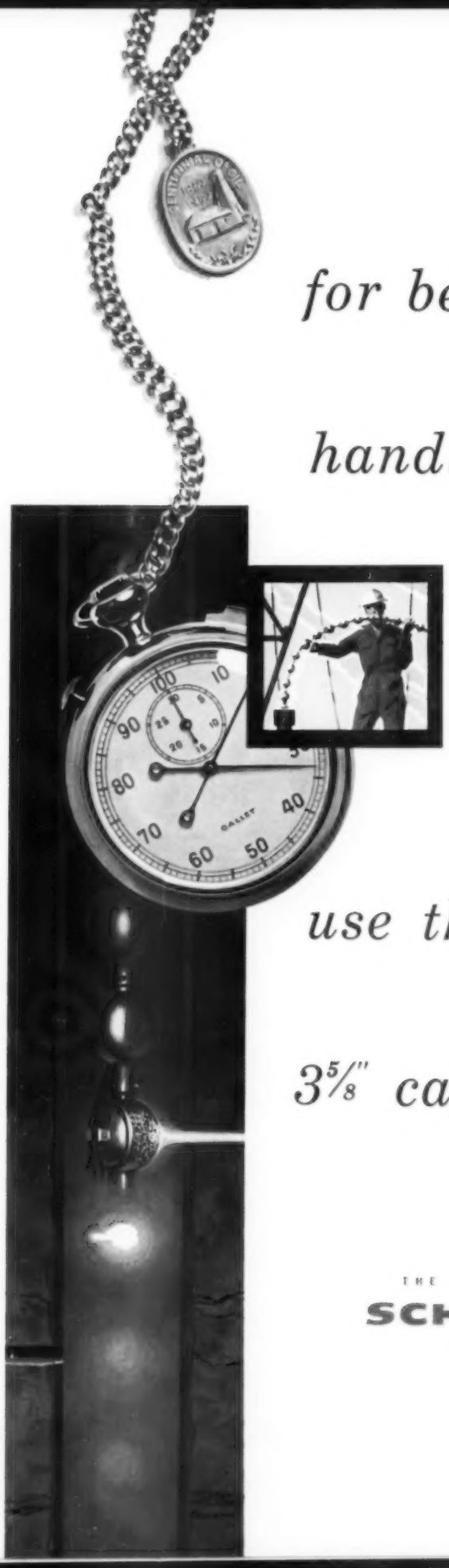
G. T. Armstrong, vice president, was transferred from Houston to Welex's Fort Worth headquarters in charge of sales and operations.

W. D. Smith, chief engineer, was transferred from Fort Worth to Houston as director of engineering at Welex's Research and Engineering Center.

H. K. McArthur was transferred from Houston to the Fort Worth operations department under H. B. Lee, operations vice president.

Other changes announced at the same time included the return of T. E. Morton, former executive vice president, to Halliburton Oil Well Cementing Company for reassignment and the resignation of Jack B. Vaughan, former sales vice president, to enter private business.

The promotions and transfers were made to better coordinate the overall efforts of the Company in research and engineering, according to Shaffer.



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CEMENTING DATA

Job — Clemile Savoy #1, Vermillion Parish, Louisiana

Owner — Continental Oil Company, Houston

Contractor: Dillard-Waltermire, Inc., Houston

Job #1 — 11,030′ of 9⅝″ O.D. casing cemented in 12¼″ hole with 1,000 bags neat UNAFLO cement. Slurry fillup behind casing 3,130′. Drilling mud wt. 11.5 lbs/gal. Schlumberger temp. log 168° F. Est. static BHT 193° F.

Job #2 — 1,298′ of 7″ O.D. liner set in 8⅜″ hole from 10,910′ to 12,208′, cemented with neat slurry 220 bags UNAFLO. Drilling mud wt. 16.2 lbs/gal. Schlumberger temp. log 196° F. Est. static BHT 226° F.

Job #3 — Squeezed top 7″ O.D. liner with 300 bags neat UNAFLO. Final pump truck pressure 2,000 psi.

Job #4 — Squeezed 150 bags Cealment (UNAFLO plus latex) through retainer set at 12,182′ into lost-circulation zone below 7″ O.D. liner.

Jobs #5, 6, 7 — Bradenhead squeeze jobs using 100 bags; 150 bags; 150 bags Cealment respectively into lost circulation zone at 12,350′. Final pressure 400 psi.

Job #8 — 2,725′ 4½″ O.D. liner set in 6″ hole from 12,017′ to 14,742′ cemented with 300 bags UNAFLO weighted (18 lbs/gal.) with HiDense #2 (Ilmenite Ore). Mud wt. 18.4 lbs/gal. Est. static BHT 284° F.

Job #9 — Full string of 7″ O.D. casing tied into top of 7″ O.D. liner at 10,910′, cemented with 50 bags neat UNAFLO.

Universal Atlas Cement
Division of
United States Steel

Glenn Advertising, Industrial Advertising Division. Glenn Advertising's new Industrial Advertising Division to service the rapidly expanding needs of technical and industrial advertisers in the Southwest will be headed by William J. (Bill) Alexander.

Mr. Alexander is widely recognized in the industrial advertising field, coming to Glenn Advertising from Continental Emsco Company where he was sales promotion manager, directing all advertising, sales promotion and public relations. He was advertising manager of the Johnston Pump Company, Pasadena, California when that company merged with Emsco Manufacturing Company of Los Angeles in 1955.

Alexander served as advertising director of the combined companies until 1957, when the merger of Continental Supply Company and Emsco Manufacturing Company took effect, and he was moved to Dallas when Continental Emsco's headquarters were established in Texas.

Rector Well Equipment Company. J. L. Pinkard, general sales manager of Rector Well Equipment Company, has announced the appointment of Frank A. Proctor, Jr. as special sales representative for the Fort Worth-Dallas area. Proctor will also serve as a company representative to the headquarters offices of the distributors of Rector Well Equipment throughout the United States.

Proctor is experienced in oil field sales and engineering. He has worked in Texas, Oklahoma, and the New Mexico area for the past 12 years, having been sales representative for Larkin Packer Company and American Iron and Machine Works. He has been a sales engineer with Rockwell Manufacturing Company for the past five years.

Security Engineering. Fred W. Dallas, Jr. has been appointed special sales representative for Security Engineering Division, Dallas-based rock bit and oil well drilling tool manufacturer, and one of the Dresser Industries. In announcing this appointment, Claude L. Griffin, vice president, sales, reported that Dallas will operate from New Orleans, handling special sales-service projects in Southern Louisiana, Mississippi, and Alabama.

For the past thirteen years, Dallas has been a sales engineer associated in drilling and production along the Texas and Louisiana Gulf Coast with Brown Oil Tools and the Dia-Log Co. A native of Houston, Texas, he trained at Georgia Tech as a mechanical engineer, and served six years as a pilot in the Army Air Corps.

National Supply Company. Kenneth L. Palmer has been appointed advertising manager of The National Supply Company, manufacturer and distributor of oil field machinery and equipment. He succeeds Allen P. Colby, who retired.

Mr. Palmer joined National Supply in 1952, after experience as a reporter and feature writer for the Steubenville, Ohio, Herald-Star. He was promoted to assistant advertising manager in 1957, with responsibility for the company's technical literature and direct mail. In his new assignment, he will also be responsible for all trade publication and newspaper advertising.

Colby has been referred to as the "dean of oil field machinery advertising." He joined National Supply in 1921 as a statistician in the accounting department. He was appointed manager of the advertising and catalog department in 1924 and was promoted to advertising manager in 1943.

During his 38 years tenure with National Supply, he has witnessed a significant improvement in the stature of industrial advertising, and has played an important part in bringing about that improvement.

Technical Oil Tool Corporation. Two new instruments for fluid-analysis developed by Halliburton Oil Well Cementing Company, the Densometer and the Pitometer, will be marketed nationally by the Technical Oil Tool Corporation, it was announced by Grover Kilgore, vice president of Halliburton, and H. H. "Pete" Peters, president of TOTCO.

TOTCO will market the Densometer and the Pitometer on a rental basis for use in oil and gas well drilling operations in the U.S.A. through its own field service organization, and through its exclusive distributors: The Continental-Emsco Company, a division of Youngstown Sheet & Tube Company and The Republic Supply Company of California. The Densometer and Pitometer combine to form a fluid-density system that provides an accurate, continuous check on fluid density and level during drilling operations.

Dodge Manufacturing Corporation. Appointment of Thomas P. Grace as sales representative for the island of Manhattan is announced by Harry A. Torson, vice president in charge of sales for Dodge Manufacturing Corporation, Mishawaka, Indiana.

Grace will work out of the New York district sales office at Room 1401, 270 Madison Avenue under the direction of James Kerr, district manager. He has had broad experience in the field of mechanical power transmission.

Born in Brooklyn, New York, he attended St. Anthony's High School, Smithtown, Long Island, and St. John's University, Brooklyn, where he studied business administration.

After serving in the United States Navy during World War II, he worked as supervisor of accounting systems for Standard Oil of New Jersey from 1946 until 1952. He joined the Morse Chain Company, Ithaca, New York, in 1953 as salesman in the New York, New Jersey and Connecticut territory. He became district sales manager for Morse a year ago.

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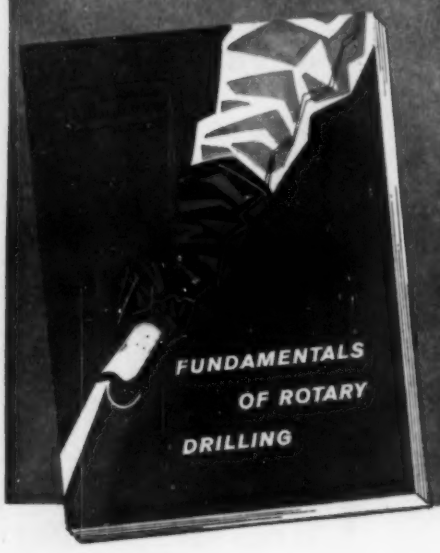

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"We have recently received a copy of your reprinted 'Fundamentals of Rotary Drilling.' This appears to be a very handy reference and we should like to know whether further copies may be obtained for our field and office group." **General Manager, San Fernando, Trinidad, B.W.I.**

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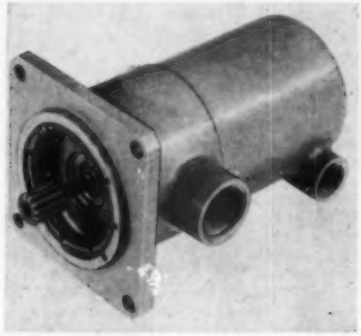
The pump features an operating range of 15,000 to 100,000 rpm and when used with a high speed turbine auxiliary power unit does not require a gear reduction unit.

The pump can handle a variety of fluids at flow rates from 2 to 30 gpm and at operating temperatures to 1000 F. Its bearings are lubricated by the fluid being pumped.

Pressure rise across the pump varies



from 1000 to 4000 psi and the pump can be supplied in 5 to 10 stages depending on the pressure requirement. A single stage version is also available which can be used as a fuel pump for small gas turbine engines.

A compact design, the pump measures 7⅝ in. in overall length by 3½ in. in diameter. The outer case is aluminum and impellers are of stainless steel. Total weight is held to 7 lb. *Turbocraft, Inc.*

Circle number (1) on reply card.

Time Base For X-Y Plotters

A new HRT-1 time base provides seven rates of sweep voltage for use with X-Y plotters. Rates are available from 0.5 mv per sec to 50 mv per sec with 2 percent accuracy, which corresponds to 2 to 200 sec for 100 mv. By resetting, the recorder attenuator sweep rates may be reduced to 1000 seconds with some loss in linearity.

Starting and resetting may be accomplished by a panel switch or a single remote contact. A halt switch is provided to stop and later resume the sweep at any time.

The unit becomes a multi-purpose chopper stabilized d-c amplifier by rotating the panel selector to "d-c amp." Current or voltage sources deliver either an amplified current or voltage output as desired by using the proper shunts. *Houston Instrument Corporation.*

Circle number (2) on reply card.

Velocity Perforating

Velocity perforating, a new method for completing oil and gas wells, has been introduced by Western.

It is a completely new method of perforating discovered by company research specialists.

Velocity perforating is based on a newly-discovered principle of relating mass and velocity to overcome the resistance of the target. The result is penetration of casing, cement, and formation. *The Western Company.*

Circle number (3) on reply card.

Diesel Electric Rig

A diesel-electric rig manufactured by a Dutch firm operates on direct current of constant amperage.

The system makes joint motive power immediately and continuously available for any combination of power consumers.

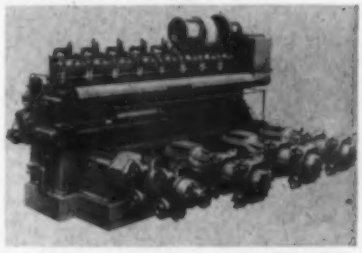
The equipment is intended for drilling depths of 10,000 to 15,000 ft. In the system, the diesel engines that drive the generators of the direct current plant have a constant rotation speed.

Electric motors control the power output, and the generators are automatically adjusted to the required power output. This is equally distributed among the generators in operation.

Diesel power required for the equipment is 850 to 1000 hp at 1000 to 1200 rpm. If gas is available, gas turbines can be used as prime movers. *N. V. Electrotechnische v/h Willem Smit & Co.*

Circle number (4) on reply card.

Engine Turbocharger



Complete field turbocharger conversion kits designed for the majority of models in Clark RA and HRA gas-engine driven compressor lines have been announced.

Depending on model, size, shaft diameter, and other design criteria, horsepower increases range from 32 percent to 50 percent on the RA Series, and from 20-36 percent on the HRA Series.

The new conversion packages provide a substantial reduction in fuel consumption per bhp and permit increased horsepower output, usually without the need for additional cooling service. *Clark Bros. Co.*

Circle number (5) on reply card.

Mechanical Shaft Seal

A reliable, economical, all-metal bellows-type mechanical shaft seal for use in rotating machinery systems, has been announced by Turbocraft.

Designated Series AMB, the unit is designed to operate in severe environments of corrosion, and in critical temperatures and pressures. It will operate effectively at pressures up to 100 psi, speeds up to 36,000 rpm, and at temperatures ranging from —400 F to 1000 F. The seal resists most corrosive bases and acids, both liquids and gases. It provides leakproof sealing of hazardous fluids such as liquefied gas and hydrocarbon fuels.

The seal is available in sizes up to 7 in. shaft diameters and can be supplied to meet special requirements for any type of compressor, turbine, or pump. *Turbocraft, Inc.*

Circle number (6) on reply card.

NORRIS

Field Tested and Approved
150 psi working pressure

WRITE FOR NEW VALVE BULLETIN
P. O. Box 1739, Tulsa

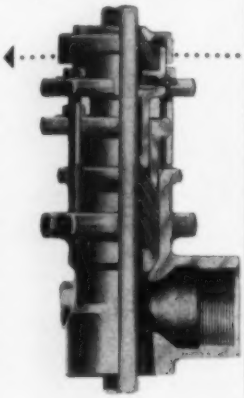
VALVES

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

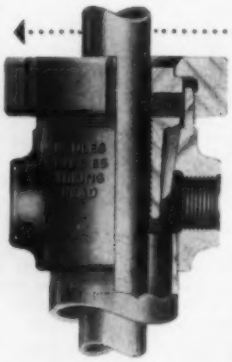
HERCULES products in ACTION

A typical set-up is shown below in Creek County, Oklahoma, using Hercules "Tee Type" Duplex Polished Rod Stuffing Box and Type "E5" Tubing Head. This is an easily assembled, effective and economical producing unit.

"TEE TYPE" DUPLEX POLISHED ROD STUFFING BOX—A combination Tee and Stuffing Box with female thread to screw directly onto the tubing, eliminating one threaded connection and resulting in a considerably shorter hookup. With internal parts removed, the Stuffing Box body is full opening and need not be removed to pull rods. In addition to being furnished in the most used sizes, special combinations of threads and outlets can be furnished on request.



TYPE "E5" TUBING HEAD—This Tubing Head is ideal for any pumping situation. It is economical enough for shallow wells and rugged enough for any depth well, with working pressure up to 1500 pounds. Hercules self-aligning slips suspend the inner string in this Head. Mandrel suspension can be furnished instead of slips, if desired, at no extra cost. A neoprene Tubing Stripper Unit is also available.



Write for complete information on any Hercules Product.

HERCULES TOOL COMPANY

MANUFACTURERS OF OILFIELD EQUIPMENT

GENERAL OFFICES AND PLANT • TULSA, OKLAHOMA

Export Representative Oil Field Equipment Co., Inc. 90 West Street, New York, N. Y.

New Equipment

Pumping Unit Control

A control unit designed to automatically control and protect squirrel-cage motors that drive oil well pumps is available from Westinghouse. The three-phase, 60-cycle, 220/440-volt a-c control unit is used on motors rated from 3 to 100 hp, NEMA sizes 0, 1, 2, 3, and 4.

The controller contains a new three-pole TC relay which gives positive protection against locked rotor, single-phase starting and running, and normal overload. The relay is insensitive to changes in ambient temperatures often encountered in oil fields and thereby eliminates nuisance trips. The temperature compensated relay allows the use of a nonventilated gasketed cabinet.

A circuit protection is provided with a de-ion grid air circuit breaker. A fault on any phase opens all three phases to prevent single phasing.

Fully automatic operation is provided, including definite time sequence restarting and 15-minute interval programming. *Westinghouse Electric Corporation.*

Circle number (7) on reply card.

Water Conditioner

A new Depp water conditioner is designed to prevent corrosion, scale formation, and iron deposits.

The chemical agent used in the treating solution has a solubility of 150 parts in 100 parts of water at 70 F, and does not raise or lower the pH of the water. One solid pound of the chemical agent will reduce 27,000 gal of water one grain.

The solution will not break down chemically in water temperatures up to 180 F. It prevents precipitation of calcium and magnesium salts in water, and will redissolve them in a system where scales have formed, the manufacturer states.

The calcium and magnesium ions in water are held in a soluble chemical combination and will not react with any soap or saponification of grease or oils.

The treating chemical is harmless to all metals and equipment, and it is nontoxic when used in drinking water. *John J. Depp.*

Circle number (8) on reply card.

Rotary Table Bushing

Solid two-piece master bushings are now available for all 20½ in. rotaries manufactured by National Supply. Developed first for the Type MS 27½ rotary, the new table bushing is now being made for Types MS-20½, and A-205 rotaries.

The solid master table bushing has a one-piece outer body and an inner bowl consisting of separately removable halves. The whole assembly can be handled in a single lift.

The new table bushing minimizes wear that is produced by the transverse force on the tapered inner bowl when supporting long and heavy drill strings. The solid outer body of the bushing prevents spreading and resultant abrasion under heavy load conditions, the manufacturer states. It also prevents possible drill pipe distortion and gouging by gripper teeth in the slips while making and breaking joints.

Reducing wear prevents the slips from dropping too far into the bushing and losing correct API taper. Deep slip marks occur in the pipe when wear causes the lower portions of the slips to be unsupported while holding the drill pipe.

Driving surfaces of the bushing are flame hardened to increase wear resistance, and all parts of the new master bushing are alloy steel castings of top quality. *National Supply Company.*

Circle number (9) on reply card.

Bulk Mud Scale

A bulk mud scale is now being manufactured by Castagnos. The operating principle involves a static pressure hydraulic system. Static pressure induced by the weight of the mud is totalized and indicated on a dial calibrated directly in sacks.

It installs easily in standard mud tanks, the manufacturer states, and it requires no alterations or modifications to the tank. Total weight of the scale is 500 lb.

A minimum of maintenance is required since there are no moving parts.

The unit is adaptable to 700 or 1400 sack tank with capacities from 70,000 to 140,000 lb, through substitution of additional cylinders under the tank. A recording indicator can also be substituted for a standard indicator where an accurate, permanent record of all mud receipts and withdrawals is required. *Castagnos Company.*

Circle number (10) on reply card.

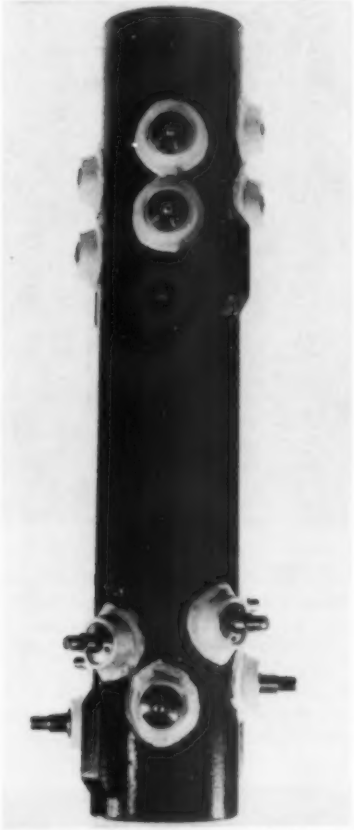
Gas Turbine Engine

An industrial version of General Electric's T58 gas turbine engine has been developed. Engines operating on liquid fuel will be designated CG 720-1, and those running on natural gas will carry the designation CG-722-1.

The engines have a maximum output guarantee at sea level of 1050 shaft hp and weight 2271 lb. The original engine was developed as a helicopter engine and was developed over a six-year period. *General Electric Corporation.*

Circle number (11) on reply card.

Perforating Method



A new field-applied method of well completion, the Permeator, provides casing perforations without damaging the cement.

When installed in the well, they create miniature pipelines from the producing formation to the well bore, eliminating all contact between well fluids and the cement behind the casing.

It is composed of a pad or blister which is welded on the outside surface of casing over machine-drilled holes. An assembly containing two concentric telescoping steel tubes is screwed into the pad.

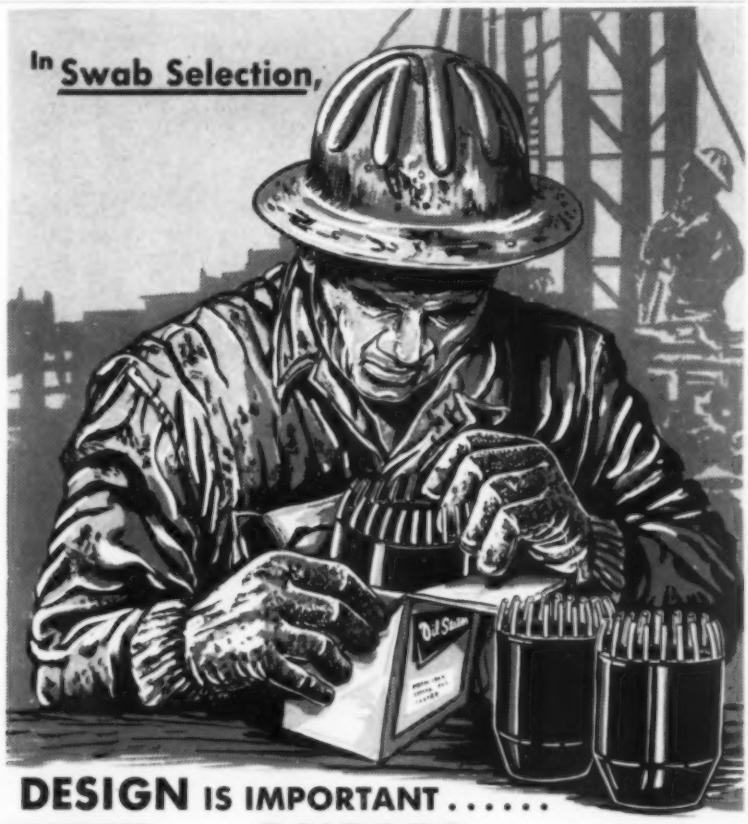
In the collapsed position the entire assembly extends ¾ in. out from the outside surface of the casing, or 1 in. on tubing. In the maximum extended position the tube extends 2½ in. from the outer surface of the casing.

Regardless of position, the assembly is flush with the inside surface of the pipe and will not interfere with cement plugs, packers, swabs, or other tools normally run inside the pipe. Externally, one in. rudders protect and guide the permeating device.

They are collapsed when the pipe is run in, and when the pipe is properly positioned opposite the pay zones and the cement displaced behind the casing, hydraulic pressure is applied to the interior of the casing, forcing the telescoped tubes to extend outward through the cement while it is still fluid, to reach the formation.

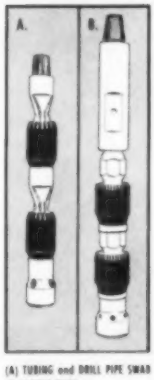
When fully extended, each device forms a steel pipeline ½-in. diam and 2½-in. long. The standard model provides an opening of ½ in. but openings from a fraction of an inch to 1 3/16 in. can be provided. *National Petroleum Company, Ltd.*

Circle number (12) on reply card.



DESIGN IS IMPORTANT . . . . . .

RUBBER IS VITAL!



(A) TUBING and DRILL PIPE SWAB
(B) CASING SWAB

Efficient Design means trouble-free operation and more fluid lifted per trip . . .

Engineered Rubber means more trips per cup, more fluid per hour.

OIL STATES pioneered the modern swab design . . . was first with the fluted mandrel . . . first with the free-moving cup for easy unloading and positive valving.

OIL STATES Swab Cups contain rubber engineered for oil field use. Compounded for swabbing by *oilfield rubber specialists* — tops in their field.

The rapid acceptance of the OIL STATES Swab is eloquent testimony to its excellence of design and superior performance. Use OIL STATES on your next swabbing job and be assured of . . . .

"Oil Field Rubber Products Of Matchless Quality."

Oil States OIL STATES RUBBER CO.

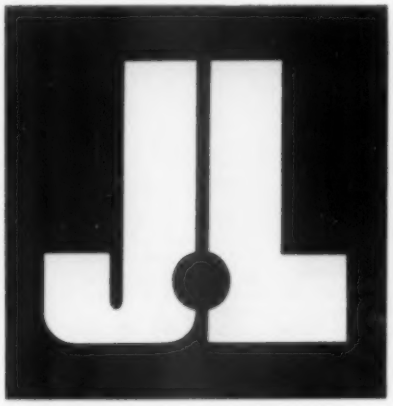
P. O. Drawer 152 • Arlington, Texas

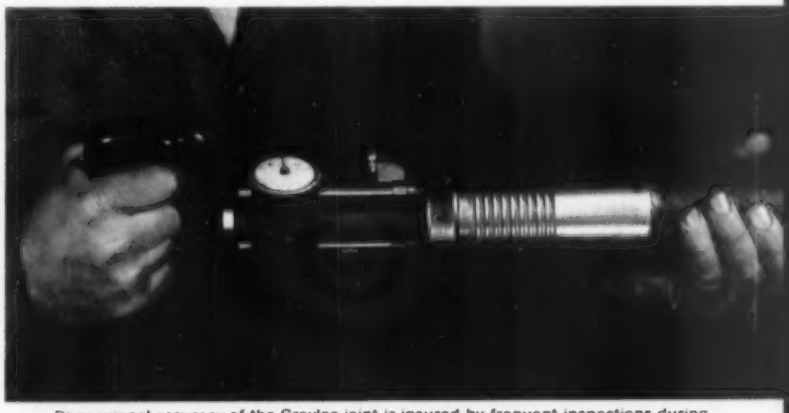
J&L GRAYLOC TUBING provides positive leak resistance at the high pressures encountered in Bright & Schiff's C. G. Joyce Well #1. Well head pressures in both zones of completion were approximately 5000 lbs. Drilling contractor, J&C Drilling Company, Corpus Christi, reported bottom hole pressures of 6300 lbs. J&L supplied 9000 feet of 2⅜-inch, J-55 Grayloc tubing, and 9400 feet of 2⅜-inch, N-80 integral joint tubing.

Independent sealing ring in each Grayloc joint provides primary sealing force.

Modified Acme-type threads provide easy stabbing, fast make-up, high resistance to damage.

Grayloc joint is machined on special facilities at J&L's Aliquippa (Pa.) Works.





Dimensional accuracy of the Grayloc joint is insured by frequent inspections during machining operations. It is available in grades J-55, N-80 and P-105.

"We used J&L Grayloc tubing because of limited clearance and high pressures encountered in this dual completion well"

. . . reports Texas driller

Producing a high pressure gas-distillate well with two tubing strings inside a 7-inch casing calls for engineering know-how and a superior tubing product. Bright & Schiff Company of Dallas, Texas, selected J&L Grayloc tubing for the job. Here's why:

Grayloc tubing, except in heavy weights, has smaller joint diameters than conventional external upset tubing. This added clearance makes the Grayloc joint especially suitable for use in multiple completion wells.

Heavy, square Grayloc threads provide easy stabbing, fast make-up and high resistance to damage. Strength of the Grayloc joint in tension exceeds that of the pipe body itself.

A separate alloy sealing ring provides the primary sealing force. The self-energized ring provides a positive, metal-to-metal seal. Grayloc joints will withstand the highest well pressures yet encountered.

For more information on Grayloc tubing, contact your nearby J&L Supply Division representative. Or write directly to Jones & Laughlin Steel Corporation, 3 Gateway Center, Pittsburgh 30, Pa.

Jones & Laughlin Steel Corporation

PITTSBURGH, PENNSYLVANIA

Variable Speed Drives

A new, low-cost line of eddy-current coupling, adjustable-speed drives from 5 to 100 hp has been announced by General Electric.

The new Kinatrol line is engineered for a broad range of industrial applications and features simplified design with fewer moving parts for longer life.

The new stepless adjustable speed drive is being offered as a complete package including the drive unit, control enclosure with control for both coupling and integrally-mounted motor, and operator's station.

Drive is factory tested as a package, pre-wired for quick, easy installation.

The motor offers versatile performance over a wide range of speeds. Ratings through 20 hp are capable of continuous operation down to 100 rpm at rated torque providing a speed range of approximately 17 to 1.

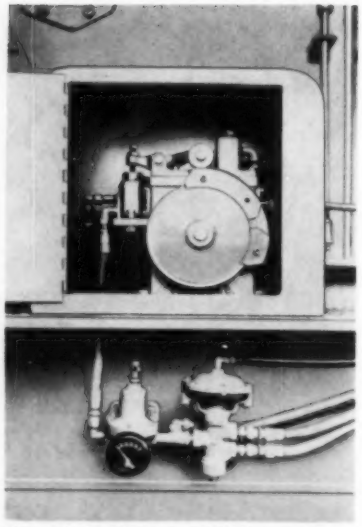
Automatic control provides close speed regulations as standard. On a typical friction type load, for example, regulation of 2 percent of full speed can be obtained with standard equipment. *General Electric Company.*

Circle number (13) on reply card.

Traveling Block Stop

A new Wilson traveling block stop automatically stops the block during raising and lowering operations.

It has a worm gear reduction unit connected by a flexible shaft drive to the drum shaft of the rig, and the worm shaft has a cam wheel. Cams can be adjustably clamped in place around the periphery of this wheel. They are arranged to contact a roller on a lever arm, which will engage a valve. When opened, it will shut off either the high or low drum clutch and engage the drum brakes by means of an air cylinder so that the drum will be quickly stopped whether it is going up or down.



When the block reaches either the top or bottom position, the stop operates and the block cannot be moved until a release button is pushed. It is held until the roller rides off the cam wheel. *Wilson Manufacturing Company.*

Circle number (14) on reply card.

Portable Air Compressor

An improved 600 cfm air compressor, the Model 600-TC, is now offered by Schramm in their unistage portable line.

The supercharged compressor is driven by a turbo-charged diesel engine which puts out over 25 percent additional hp.

The unit has a single liquid cooling system which circulates through the entire unit. Since engine and compressor are connected by a hand-operated clutch, the system permits both the engine and compressor to be brought up to operating temperature before being placed under load.

Standard equipment includes electric starter with 12 volt battery and generator, lubricating oil filters on both engine and compressor, liquid cooling system with shrouded fan and coolant pumps, ASME Code air receiver and fuel tank, lockable sliding doors, and a Schramm pneumastat which automatically regulates the speed of the unit in accordance with the demand for compressed air placed on it. *Schramm, Inc.*

Circle number (15) on reply card.

Brass Gate Valve

A new brass gate valve uses two O rings in place of ordinary fiber asbestos packing. The rings are placed in an O ring seal plate, the top serving as a dirt seal and the bottom as a fluid seal.

The slotted flexitite disc has a slight flexibility, which automatically compensates for small misalignment of seat faces. This assures a leaktight contact over the entire seat face.

It is designed for general service on lines where straight-through flow is desired. *Modern Utility Supply Company.*

Circle number (16) on reply card.

WISCONSIN-POWERED pump speeds filtration in disposal and water flood projects

This application typifies the adaptability of Wisconsin Engines for oil field jobs. And it proves that now you can enjoy the benefits of trouble-free air-cooled power on jobs in the higher hp range.

The Wisconsin-powered pump meets the need for efficient, low-cost filtration of water prior to injection into sub-surface formations. Used extensively in both disposal and water flood projects, the unit periodically backwashes the filter at a rate of 1160 gpm at 50 ft. tdh.

Like all Wisconsin Engines, the powerful VR4D is custom-engineered for the job. It's a heavy-duty precision-built unit in every detail. It is designed to work better and to last longer. Since it is air-cooled, you can depend on it in sub-zero cold or in 140° F. heat.

Look at the features . . . a 12-volt electric starter for fast, easy starts . . . cut-out switches that automatically protect the engine against damage due to low oil or high temperature conditions. Stellite valves and inserts and valve rotators extend valve life up to 500%.

Specify Wisconsin air-cooled Engines on your utility units. Choice of single-, two-, and V-type four-cylinder models — 3 to 56 hp. Tell us your needs and we will tailor the engine to your machine or job.

WISCONSIN MOTOR CORPORATION
MILWAUKEE 46, WISCONSIN
World's Largest Builders of Heavy-Duty Air-Cooled Engines

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Oil Field Distributors for Wisconsin Engines and all types of Utility Units

56-HP VR4D ENGINE with clutch take-off assembly, is direct-connected through a flexible coupling to a 5 x 6-R Mission aluminum-bronze centrifugal pump.

J-113

Heated Centrifuge

L-K Pump Valve has introduced a line of new electric heated centrifuges for operation by direct current.

The new models are more compact and lighter in weight. A new low profile is

used, and the centrifuges are constructed of aluminum.

Controlled heat is supplied to the cups throughout the spinning operation and both heat and motor switches are equipped with indicator pilot lights. *L-K Pump Valve Company.*

Circle number (17) on reply card.

Epoxy Repair Kit

Epi-SEAL Epoxy Resins are now offered in a compact, easy-to-use Oil Repair Kit. The resins have been in use for more than five years in oil field repairs.

Repairs can be made without freeing gas, where this is a hazard, and no special tools or skill are necessary. The kit contains epoxy resin, glass tape, two types of reinforcers, stirrers, brushes, gloves, sandpaper, non-sparking wire brush, solvent, and instructions for use. There is sufficient material in each kit for about 12 average repairs.

Uses include repairing cracked welds on pontoons for floating roofs, leaking seams and rivets on storage tanks, corroded areas in casing tubing and pipe, hole in tanks, fittings, valves, piping, faulty threads and welds, leaks on oil transports and trucks. *Bonded Products, Inc.*

Circle number (18) on reply card.

Vinyl Ball Valves

Successful use of rigid vinyl ball valves in piping systems where corrosion has long been a problem has been announced. Except for seats and seals, valve is made of Geon, vinyl material. It offers superior resistance to oils, acids, alkalies and most chemicals. Thousands of test cycles conducted with new valve have proved effectiveness of its seal either at full pressure or vacuum. Available with threaded ends, weld ends or flanges, vinyl valves are self-compensating for changes in pressure or temperature. There is no problem of galling or seizure and no lubrication is needed. *B. F. Goodrich Chemical Company.*

Circle number (19) on reply card.

Fluid Type Auxiliary Brakes

Two sizes of fluid type auxiliary brakes, a series 420 and series 520, are now being produced by Fluid Brake.

The 420 series is normally used for drilling depths to approximately 15,000 ft, and the 520 for deeper drilling on heavier rigs. *Fluid Brake Company.*

Circle number (20) on reply card.

Continuous Readings In Hydraulic Fracturing

Two new instruments, the Halliburton Fracometer and Densometer, provide both visual and permanent continuous recordings of fluid injection rate, well-head pressure, hydraulic horsepower, and ratio of sand to fracturing fluid.

The Fracometer is a unitized instrument that employs a pneumatic pressure pickup connection to measure well-head pressure, a flow-meter to measure injection rate in bbl per minute, and a pneumatic analog computer to calculate hydraulic horsepower delivered to wellhead.

The Densometer reports ratio of sand to fluid in terms of fluid density. It is an adapted version of an instrument originally developed to weigh cement slurry and drilling mud.

Treatment may be modified on the spot using the fast readings. Also, a fracturing treatment that involves more than one injection rate, type of fluid, sand ratio, or other factors is simplified. *Halliburton Oil Well Cementing Company.*

Circle number (21) on reply card.

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EXPLORATION ACTIVITIES

GREECE

Esso and Greece Sign Exploration Pact

The Greek government and Esso Hellenic Inc., a U. S. corporation wholly-owned by Standard Oil Company (New Jersey) have signed an agreement granting the corporation exploration and development rights in certain areas of Greece. The agreement must be ratified by the Greek Parliament.

Operations of the corporation will be conducted on an area of approximately 4000 sq km located in the general area of the islands of Paxi and Zakynthos off the southwestern coast of Greece, and in the areas of Killini and Pylos in western Peloponnesia.

It has been agreed that the corporation will spend a minimum of $6.4 million if operations are continued over the first 8 years. If at the end of 8 years no discovery has been made, the entire area will be surrendered to the Greek State. Duration of the development concessions, to be selected by the corporation in case of discovery, will be 30 years with the possibility of a 10-yr renewal. This agreement represents a 50-50 venture in which the Greek State will receive 50 percent of the net profits of the corporation, including a royalty of 12½ percent.

ALASKA

Details of Kenai Discoveries Revealed

Production rate of the first commercial natural gas well in Alaska is far greater and the proved producing area more extensive than originally believed, as revealed by Union Oil Company of California and Ohio Oil Company, partners in the property on the Kenai Peninsula southwest of Anchorage.

The discovery well, Kenai 14-6, was drilled to a total depth of 15,047 ft, deepest hole drilled in Alaska. When a fishing job made it necessary to abandon the lower portion of the hole, 7-in. casing was cemented at 4616 ft and perforated at 4455-4590 ft. The discovery flowed dry gas at the rate of 31,000 Mcf per day through a ⅞-in. bean with tubing pressure of 1650 psi on production test.

A second well, Kenai 34-31, was drilled to 5809 ft. Seven-inch casing was cemented at 4950 ft and perforated at 4720-4894 ft at intervals. Located a mile north of the discovery, this well flowed at 17,000 Mcf per day through a ¾-in. bean with tubing pressure of 1250 psi.

Kenai 33-30, the third well, was drilled to a depth of 5011 ft and 7-in. casing set. Production tests are in progress.

Koyukuk Basin Is Site of New Test

Paul G. Benedum of Pittsburgh, chairman of a group of independent oil companies and individual operators who are carrying on a joint exploratory operation in Alaska, announced that drilling is underway on the group's Nulato Unit No. 1 well.

Located in the Koyukuk Basin in the west central part of the forty-ninth state, the well is projected to a depth of 12,000 ft. It was spudded in Nov. 29.

LOUISIANA

Four-Zone Gas Discovery In Gulf of Mexico

Sinclair Oil & Gas Company, a producing subsidiary of Sinclair Oil Corporation, has completed a four-zone gas discovery on a 5000-acre block about 35 miles off St. Mary Parish in the Gulf of Mexico. The well, No. 5, Block 190, Eugene Isle, is the company's first 4-zone completion. Production is from 4 zones perforated in the Miocene sand from 8844 to 9350 ft.

On calculated open flow tests, the well flowed 44,200,000 cu ft of gas daily from 8844-52 ft; flowed 64,000,000 cu ft of gas daily from 9062-72 ft; flowed 52,800,000 cu ft of gas daily from 9223-32 ft; and flowed 3,200,000 cu ft of gas daily from 9337-50 ft.

The federal lease block is owned one-fourth each by Sinclair, the opertor, El Paso Natural Gas Company, Sohio Petroleum Company, and Peoples Production Company.

Companies Join In Gulf Exploration

Ocean Drilling & Exploration Co. (Odeco) and its parent Murphy Corp. have joined with Burmah Oil Western Co. in an "ambitious" wildcatting program in the Gulf of Mexico off Louisiana, mainly on farmouts, A. J. Laborde, Odeco president, has announced.

Commitments have been made for four farmouts and drilling has begun on the first of these, with plans to drill the others shortly. Additional prospects were said to be under study.

Laborde predicted that Odeco would begin oil sales from its Eugene Island Block 110 field production by about June of this year.

TRINIDAD

Discovery Sparks Broad Development Plans

Encouraged by results of its discovery well in the East San Francique area late in December, Panoil Company is planning to expand its operations in Trinidad during 1960. The expansion will include both increased drilling and a waterflooding project. Panoil has been operating in Trinidad since June 1959 under a management contract with Premier Consolidated Oil Fields, Ltd., of London.

The discovery well, East San Francique No. 4, was completed at 800-830-ft, flowed 250 bbl of 23-gravity oil in 15 hr through 12/32-in. bean, with tubing pressure of 150 psi and casing pressure of 310 psi. The well found three other shallow sands, still to be tested.

Twelve additional locations have been made for drilling early in 1960. The company holds several thousand acres in the area.

Activity Begins Off Island's West Coast

An offshore exploratory drilling program is being inaugurated on the 5700-acre marine license off the west coast of Trinidad which is owned by Kern Trinidad Oil Fields, Ltd. and in which Christiana Oil Corp. has a 15-percent net profit interest. Kern Trinidad is a subsidiary of Rio Tinto Co. Ltd.

Zapata Offshore Company, which has been engaged to drill an indefinite number of wells, three of which will be approximately 5000 ft, 7400 ft, and 9800 ft from shore, respectively, had a mobile drilling barge en route to the area due for arrival January 1. The first well will be approximately 5000 ft from the west border of the license and approximately 5000 ft from shore.

CALIFORNIA

Continental Continues Movie-Lot Drilling

Continental Oil Company is drilling the second well in its recently discovered Culver City oil field. The development well, the M.G.M. No. 2, is being drilled on the Loew's, Inc., Culver City M.G.M. studio property. Continental perforated the discovery well in late November and tested an interval from 8660 to 8807 ft at a 720-bbl per day rate of 24.4-deg oil from a new producing sand for this part of the Los Angeles Basin. The sand has been named the Culver sand, and is absent in the nearby Inglewood oil field.

PATENTS APPLIED FOR

Programmed Hydrocarbon Detector ... the hottest thing in mud logging!

Core Lab's new **P/H/D** eliminates the two biggest problems heretofore present in making chromatographic separations of hydrocarbon components—(1) the length of time required to completely "spell out" the heavier hydrocarbons; (2) the low concentrations of heavier hydrocarbons encountered (and the flattening out of heavy hydrocarbon peaks).

For example, **P/H/D** — utilizing an exclusive technique of back-flushing a single column after the desired hydrocarbon has been read — measures methane, ethane, and propane in 1-2-3 sequence (plus heaviers) in *only three minutes!* And, in the meantime, the column is automatically prepared for the next sample.

Heavier hydrocarbons which are normally encountered in low concentration can be grouped together. The width of the composite heavier component peak is compressed by back-flushing, making the peak on the recorder chart *higher and more apparent.* Result—fewer 'lost' shows.

Here, at last, is an electronic system for detecting and selectively analyzing *total gases* in rapid-fire order. And the beauty of it is **P/H/D's** simple put-together — sturdy, compact, dependable.

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TEXAS

Gas Distillate Wildcat In Brazoria County

A successful gas distillate well has been completed near Angleton in Brazoria County. On drillstem test, the San Jacinto Oil & Gas Company-D. C. Bintliff No. 1 flowed through a 12/64-in. choke at a potential daily rate of 1.5 million cu ft of gas. It was estimated the gas would produce 20 bbl of condensate per day.

Production is from perforations in the McCarthy sand between 10,848 and 10,858 ft. There are two lower high-pressure gas zones plugged back for later completion in the 15,730-ft hole. Shows of oil were found above the McCarthy. Shut-in pressures were 3674 psi at the bottom and 3050 psi on the tubing. Flowing tubing pressure was 1950 psi.

The wildcat is ¾ of a mile from nearest production, both east and west. Drilled by Dillard and Waltermire, of Houston, it is located 4700 ft west and 3000 ft south of the northeast corner of the Samuel Carter survey, A-53, in Bailey's Prairie field, on David C. Bintliff's 4500-acre Bar X Ranch.

State Discoveries Up in 1959

Texas operators discovered 392 oil and 69 gas fields in 1959 compared with 373 and 64 in 1958, but other drilling statistics trailed year-earlier figures, according to a summary prepared by the Texas Railroad Commission.

Oil and gas discoveries in the final week of 1959 totaled 8 and 4, respectively, against 4 and 1 in the previous week.

Discovery Will Be Triple Completion

R. J. Caraway, Dallas, and Pan American Petroleum Corporation are owners of a new 3-pay discovery, the No. 1 W. A. McCoy, James Cheshire survey, and a 3500-acre leasehold around it. Location is less than a mile southeast of the town of Fruitvale and some 4 miles northwest of the Fruitvale pool.

Completion is planned for the Cotton Valley (Jurassic) through casing perforations at 10,522-32 ft in the top 10 ft of a 20-ft pay section; the James (lower Cretaceous) lime through perforations at 8286-93 ft in a 10-ft pay section; and the Rodessa (also lower Cretaceous) through perforations at 8814-94 ft covering all of a 10-ft section.

On a preliminary test of the Cotton Valley holes, the well showed 2,170,000 cu ft of gas daily through 12/64-in. choke with 2800 psi flowing pressure. Estimated daily crude oil yield for the James section on preliminary testing through ¼-in. choke was 200 bbl with flowing pressure 225 psi and shut-in pressure 1650 psi. Estimated oil yield for the Rodessa was 300 bbl per day through ¼-in. choke with working pressure 300 psi.

Confirmation Well Extends Gas-Producing Formation

Another extension of the Tonkawa gas-producing formation in the Kiowa Creek area of Libscomb County has been announced by officials of Falcon-Seaboard Drilling Company. The Duke #1-857, a diagonal offset to Falcon's Duke #1-817 discovery in Block 43 of the H. and T.C.R.R. Company survey, gaged 9.4 million cu ft of gas per day from a total depth of 7450 ft. Pipe was set at 7448 ft and perforations were made at 6402-08 and 6416-24 ft in the Tonkawa sand.

After fracturing with 55,000 lb of sand and 20,000 gal of gelled water, the well showed a potential of 9,400,000 cu ft of gas on a calculated open flow test. On a ⅝-in. choke, flow was measured at the rate of 3,179,000 cu ft with a flowing tubing pressure of 1461 psi.

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UTAH

Grand County Gas Well Is Completed

Sunray Mid-Continent Oil Company is preparing to run production string at the No. 1 Utah Federal "B," a 3-mile semi-wildcat stepout located on a 46,000-acre block in Grand County.

On a 3-hr test, the well flowed an estimated 5,181,000 cu ft of gas a day through ¾-in. choke from the Dakota sandstone testing a drilling break interval from 7254-70 ft. Tubing pressure gaged 360 psi.

The well, located SW NE NE Sec. 23-17s-22e, was drilled on the large block which is 3 miles west of the Westwater multiple-pay gas field.

Pure Oil Discovery In San Juan County

Pure Oil Company has completed its Northwest Lisbon No. 1 discovery well in San Juan County as a substantial oil producer with initial production of 586 bbl per day.

The oil flow came from 70 ft of perforations in the McCracken sandstone of Devonian age from 8261-93 ft and from 8310-48 ft. Production was through a 14/64-in. choke, and flowing pressure on the tubing was 250 psi. The 45.2-gravity oil contained no trace of water or sediments.

Earlier, from 7539 to 8235 ft, the Northwest Lisbon well had encountered almost 700 ft of Mississippian limestone, practically all of which showed evidence of commercial quantities of natural gas on tests. The company, however, has decided not to produce the gas from this well at present.

CANADA

Canada Predicts 10-Year $200 Million Exploration

Officials of the Department of Northern Affairs and National Resources predict the following picture for exploration activities in Canada during 1960:

Additional oil and gas exploration permits will be issued for the northern mainland with the expectation that perhaps $200,000,000 will be spent in the next 10 years in exploration alone. Acreage under permit totaled more than 92,000,000 with more than 50 crews at work last summer and perhaps 20 wildcats will be drilled this winter.

In the Arctic Islands, farther north, applications for oil exploration permits zoomed to 105,000,000 acres near the end of the year. Under these permits, larger-scale exploration is expected and drilling, it is anticipated, may start in the next 2 years.

Well Spudded In North Of Arctic Circle

The most northerly well ever drilled in Canada was spudded on December 26, according to an announcement by Richfield Oil Corporation, operator for the 5-company group drilling the well. Richfield, French Petroleum Company of Canada Ltd., Clark Oil and Refining Corporation, and Hudson's Bay Oil and Gas Company Ltd. all participated equally in the recent acquisition of an 85-percent working interest in approximately 3.5 million acres located in the Lower Mackenzie Basin area of the Northwest Territories from a group headed by Scurry-Rainbow Oil Ltd. Canadian Devonian Petroleum, Ltd. holds the remaining 15-percent working interest.

The well, Richfield Oil Corporation et al Grandview Hills No. 1, is located approximately 45 miles north of the Arctic Circle and is only 175 airline miles from the Arctic Ocean at Mackenzie Bay. It is being drilled by Peter Bawden Drilling Ltd.

Additional geophysical and surface geological work will be carried on next summer in an attempt to develop prospects for future drilling to be done as part of the joint exploration program.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Exploration

KENTUCKY

"Gusher" Steps Up Area Activities

A well drilled by Lewis Horn of Chicago and others on the Clinton County farm of State Rep. Clete L. Garner near Albany blew in out of control January 2 and produced an estimated 20,500 bbl of oil in its first 36 hr of operation.

The blowout occurred after the cable-tool rig topped the Stone's River limestone of Silurian age at 1012 ft and stopped digging. Oil under pressure of 2500 to 3000 psi burst through moments later and soared 150 ft into the air. Flow was controlled by capping several hours later.

It was observed that the discovery might outproduce Kentucky's famed Wilson-Cooper well which was drilled in the 1930's in an area now inundated and yielded up to 10,000 bpd of oil.

SPAIN

Spanish Concessions Let to Four Companies

A new law in Spain has resulted in the granting of first concessions to four groups of companies. Largest parcel was an 11-block tract of 156,000 acres awarded to Cia. Petrolifera Iberia, in which Sun Oil Company and Union Oil of California have two-thirds interest, located in Alava, Guipuzcoa, Navarra, and Vizcaya.

Ten blocks covering 130,000 acres in Barcelona and Lerida were awarded to an affiliate of Standard Oil of New Jersey. A subsidiary of Gulf Oil Company won 104,000 acres in 10 blocks located in Barcelona and Lerida provinces in a joint concession with Diehlmann of West Germany.

Campsa, the government company, received 7 blocks as a result of applications made with Caltex. The 88,000-acre concession is located in Santander and Burgos.

LIBYA

Mobil Affiliate in Joint French Sahara Venture

Mobil Oil Company has announced that one of its affiliates in France has signed a preliminary agreement with a French company, Compagnie d'Exploration Petroliere (C.E.P.) and associated companies for a 25-percent interest in petroleum rights to approximately 8 million acres in the French Sahara.

The petroleum rights area is located along the Libyan border of the Sahara, in the Department of the Oases, between the Edjele and Hassi Messaoud oil producing areas. It is approximately 300 miles from the Mediterranean and 100 miles north of the Edjele oil field. The petroleum rights area contains 4 permits. Their total area is roughly twice the size of the state of Massachusetts.

SEG Sets International Meeting Dates

The Society of Exploration Geophysicists has accepted the invitation of its New Orleans section, Southeastern Geophysical Society, to hold its 33rd annual international meeting in 1963 in New Orleans, according to T. O. Hall, General Geophysical Company, Houston, SEG president. Hall set the dates of the conclave for October 20-24, 1963, with the Roosevelt and Jung hotels as combined headquarters.

New Orleans was chosen from three cities whose invitations for the 1963 convention were presented to the SEG council during the 29th annual meeting in Los Angeles. "One of our most successful meetings was held in New Orleans in 1956," Hall said, "when more than 2000 delegates assembled there from all over the world."

The SEG is scheduled to meet November 7-10, 1960, in Galveston, Texas, and international meets have been set for Denver in 1961 and Calgary, Alberta, Canada, in 1962.

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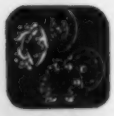

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CLUTCHES

AOSC Attacks "Kickback" by Contractors

A RIGID CODE of ethics designed to eliminate "kickbacks" by oil well servicing contractors to major company or independent producer personnel was recommended at the fourth annual convention of the Association of Oilwell Servicing Contractors held recently in Dallas.

The recommendation was made by J. A. Sutcliffe, of ROWSCO, Inc., Russell, Kansas servicing firm in which he is a partner. His speech was the lead-off of the organization's two-day meeting which attracted around 300 members and associates.

Sutcliffe said servicing contractors must learn the necessity of applying sound business practices to their operations. If they don't recognize the need for sound business principles and high ethical standards, he said "there is no limit to the depths to which (our) industry will fall . . ."

After pointing out how servicing contractors need systems that will show them their costs of doing business, and also illustrating spiraling operating costs for servicing contractors, Sutcliffe said some contractors "frantic to stay in business" have resorted to "unethical business practices."

Sutcliffe said there are "too many self-termed rugged individualists" in the servicing business who "stoop to bribery and kickbacks to get work." Published price schedules by these contractors, he said, "are a farce."

He described how some of these contractors charge by the hour for their crews and equipment, and then "load their time as much as the traffic will bear."

Such practices, Sutcliffe warned, have placed the servicing industry in a bad light. Servicing contractors, he added must clean house so they can earn and hold the respect and confidence of oil producers.

Sutcliffe pointed out how many of the majors and independents are becoming aware of the kickback situation and realize such operations are costing them money. He added, however, that reputable contractors are plagued with complacency by many oil company area or district officers regarding this.

Sutcliffe said most companies expect the contractors to make a profit from well servicing, but "they expect honesty and integrity from contractors with whom they do business."

To get this, he suggested AOSC has the power and authority to demand that its members strictly adhere to an ethical practices code. The paramount purpose of the association, he added, should be to develop such a code and make its members follow it as a condition of membership.

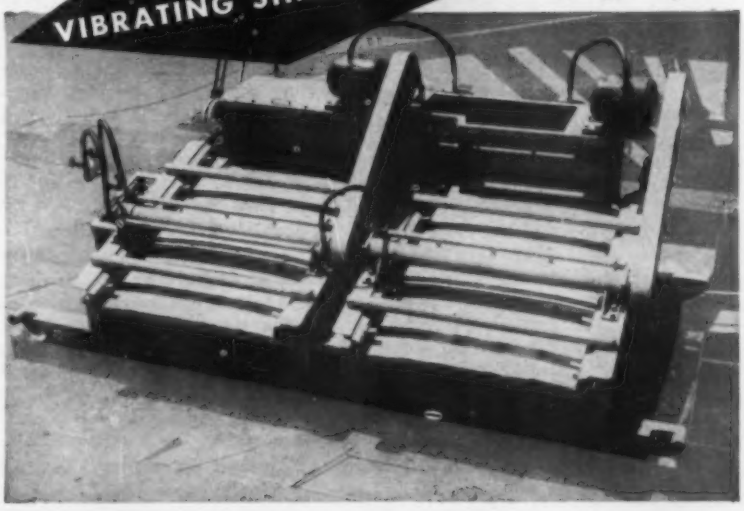
He said each member should be required to make available to an authorized AOSC representative, as well as to customers, his payroll records and invoice records so that it would be determined whether charges had been "padded" or invoices "boilerhoused."

Violations, in Sutcliffe's recommendations, would result in loss of membership and publication of such dismissal in the association's magazine.

Oil producers would then learn to respect the AOSC insignia and would feel they were getting their money's worth when employing an AOSC member to do their well servicing, Sutcliffe said.

For The "MR. CAP" They Chose a

Thompson VIBRATING SHALE SHAKER



Thompson . . . Perfect for Offshore Work!

On offshore rigs the reclamation of mud is vitally important and the separation of shale and abrasives from drilling muds means a more effective, time and money saving drilling job. Barnwell Offshore, Inc. chose Thompson for their new offshore rig, the MR. CAP, because it was field proven, will give them clean mud and make tools last longer, with a minimum of re-tooling and restoration of mud solution.

A Thompson Separator is your surest bet onshore . . . offshore . . . for shallow, medium and deep wells. The dependable Sample Machine works simultaneously with the separator, giving a foot-by-foot mud analysis with specimens. Write for Folder.

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What's doing in DRILLING

$5,000,000 Mobile Unit Commissioned at Qatar

The Seashell, $5,000,000 mobile oil-drilling platform built for Shell as a more versatile successor to the one wrecked in a sudden storm three years ago off Qatar, in the Persian Gulf, was commissioned recently in Doha Bay, Qatar.

During commissioning ceremonies, His Highness Sheikh Ali Bin Abdulla Al Thani, ruler of Qatar, cut a tape to start the drilling machinery after both the Qatari and Shell flags had been hoisted. A. J. Miller, a director of Shell Company of Qatar Limited, and M. W. Godfrey, general manager, attended the ceremony.

Two Dutch tugs towed the Seashell 6400 miles to Doha Bay from Schiedam, Holland, where it was built. The trip took 75 days at an average speed of 3½ knots. Mostly good weather was encountered, but a head-on gale in the Red Sea halted progress temporarily.

During the journey, five men from the towing contractors were aboard 5930-ton mobile platform. Two Shell engineers maintained the platform machinery.

The Seashell has a pontoon 209-ft long, 105-ft wide, and 17-ft deep, with eight legs 218-ft long and 10-ft square. It was designed to withstand gales up to 100 miles per hour and waves 30-ft high while working in water 100-ft deep.

The pontoon hull carries drilling machinery suitable for drilling to depths of 17,000 ft and servicing equipment, which includes a 75-ton completely mobile crane. It has a detachable helicopter deck which projects over the water and can be folded away before making long tows.

Before the first platform was wrecked, the rig had drilled two exploratory wells in Shell's marine concession off Qatar. This venture has cost $21,000,000, and results have been disappointing.

Seashell will be towed out to a new drilling site about 50 miles offshore and commence operations on the new well. Target depth is about 7000 ft.

Electronic Device Finds Buried Undersea Flowlines

One of the latest developments in Louisiana offshore oil operations is a 6-ft, 200-lb device for detecting buried undersea metal.

Called a fish, it is an electronic metal locator designed by Shell Development Company in Houston to track down gathering flowlines which bring oil from producing wells to production platforms in offshore fields.

It was designed for use in Louisiana coastal waters where there is a network of well over 350 buried undersea flowlines. Difficulty in detecting the exact location of these lines presented the constant danger of breaking one when installing a new offshore drilling structure.

The device is dragged across the bottom by a cable connected to the stern of a tow boat to determine a clear area. A recorder aboard ship shows ferrous metal objects which pass under the fish and the recording equipment is calibrated to allow calculation of the depth of the object.

The device operates on the electromagnetic field principle, recording permanently when the field is disturbed. It has special innovations that allow it to function normally in salt water and over varied soil formations, and it can measure the depth of a pipeline to within three to six inches.

Nola 2 Washed Ashore, Damaged in Mexico Storm

A series of storms wreaked havoc along the coast of Coatzacoalcos, Mexico, causing considerable damage to offshore operations in the area.

The Nola 2, over-the-side drilling barge owned by Zapata Off-Shore Company, was caught in a severe storm of hurricane velocity and was washed ashore dragging its anchors. Divers and salvage crews are evaluating the extent of damage, and provided it can be salvaged should be back in operation in about four months, George H. W. Bush, president of Zapata, estimated.

A mobile platform was damaged, a derrick barge, and two deck barges were washed ashore during the storms. All drilling operations in the area were considerably delayed.

Automatic Well Controls Installed in Venezuela

A new electronic supervisory control system, designed and built by Southwestern Industrial Electronics Co., a division of Dresser Industries, Inc., Houston, Texas, is being installed for the Phillips Petroleum Company on a 20-well lease in one of its Lake Maracaibo, Venezuela operations.

The rugged unit is modular constructed to be compatible with further automatic control instrumentation, which may be added as needed.

With the installation of the automated system at Maracaibo, officials anticipate that the lease will produce over 8000 bbl per day per well, or a total of about 160,000 bbl per day for the entire lease.

Rotary Rigs Operating in Oil Fields of United States and Canada

As reported to American Association of Oilwell Drilling Contractors by Hughes Tool Company

	Dec. 14	Dec. 21	Dec. 28	Jan. 4
Alabama	5	5	5	5
Arkansas	18	13	13	14
Arizona	0	0	0	0
California—Land	90	83	80	71
California—Offshore	7	6	7	7
Calif.—Total	97	89	87	78
Colorado	36	43	39	39
Florida—Land	2	1	1	1
Florida—Offshore	0	0	0	0
Florida—Total	2	1	1	1
Illinois	47	41	33	34
Indiana	5	7	[illegible]	7
Iowa	0	0	[illegible]	0
Kansas	133	139	139	123
Kentucky	10	10	10	10
North Louisiana	39	42	32	30
South Louisiana				
Inland Waters	112	110	113	100
South La.—Land	116	101	98	95
South La.—Offshore	54	56	54	51
La.—Total	320	307	297	286
Maryland	0	0	0	0
Michigan	35	42	41	37
Mississippi	79	79	77	68
Missouri	1	0	1	1
Montana	25	23	22	18
Nebraska	29	27	29	24

	Dec. 14	Dec. 21	Dec. 28	Jan. 4
Nevada	0	0	0	0
New Mexico	132	115	113	114
New York	0	0	0	0
North Dakota	28	31	30	25
Ohio	0	3	3	4
Oklahoma	255	238	194	188
Oregon	0	0	0	0
Pennsylvania	12	13	14	14
South Dakota	4	4	4	5
S. Tex. & Gulf C.—				
Inland Waters	6	8	[illegible]	[illegible]
S. Tex. & Gulf C.				
Land	[illegible]	[illegible]	175	[illegible]
S. Tex. & Gulf C.—				
Offshore	0	0	0	0
North & East Tex.	200	193	165	160
West Central Tex.	236	229	210	218
West Texas	135	116	99	101
Texas—Total	775	760	655	662
Utah	30	30	30	27
Washington	1	1	1	1
West Virginia	4	3	4	4
Wyoming	81	72	63	64
Total—U. S.	2181	2117	1913	1853
Western Canada	213	218	222	223
Eastern Canada	1	1	1	1
Grand Total	2395	2336	2136	2077

TUBINGLESS COMPLETIONS NEED.....

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TUBING SPACER INSTALLATION

As tubingless well completions and slim hole operations have become more and more popular, many problems have arisen in connection with the reduced diameters now required in small downhole casing equipment and accessories.

To keep pace with this need, Halliburton is continually developing and improving its comprehensive line of equipment specifically designed for tubingless completion work . . . Some of which are:

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AND MANY OTHER TUBING ACCESSORIES

available for tubingless completions include the Halliburton Full-Flow Packer Shoe, Cement Basket, Latch Down Tubing Plug and Adapter, Tubing Guide Nose – and many more items now under development.

Designing and manufacturing new small downhole tools required for tubingless well completion work is just another way in which Halliburton serves you. Ask your local Halliburton Representative for more details on these or other equipment and service you may need.

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Drilling

Census Bureau Reports Sharp Increase Offshore

Offshore oil and gas operations have increased sharply, in the last few years, the U. S. Census Bureau reports, and federal land sales this month of about 1,608,000 submerged acres off Texas and Louisiana should stimulate drilling further.

In a preliminary report, the agency said that shipments of crude petroleum from offshore operations totaled 58,000,000 bbl in 1958, a 104 percent increase over 1954. Production of offshore natural gas in 1958 totaled 231 billion cu ft, a jump of 197 percent over 1954.

Cost of drilling and equipping offshore wells completed last year amounted to $183,000,000, an increase of 168 percent since 1954. Footage drilled increased by 80 percent to 3,993,000 ft in 1958. The average footage drilled per well increased from 8940 in 1954 to 9644 last year.

Average cost per well for drilling and equipping rose from $276,000 to $442,000.

An offshore well, for census purposes, was defined as one which is bottomed at, or produced from, a point which lies seaward from the normal or ordinary coast line.

The number of offshore wells producing in December, 1958 was given at 1705. They consisted of 1599 oil wells and 106 gas wells. The number producing in December last year by states included Louisiana, 831 oil wells and 89 gas wells; Texas, 14 oil and 17 gas; and California, 754 oil, the federal government reported.

New competitive oil leasing on federal-controlled acreage consists of 288 tracts in two zones off the Louisiana shore, and 97 tracts off Texas.

Minimum acceptable bonus bids will be $15 an acre for tracts ranging in size from "a few fractional blocks" to the regular-size blocks of 5000 acres offshore Louisiana and 5760 acres offshore Texas.

Deepest Producing Well In Texas Completed

The deepest producing well ever drilled in Texas has been completed.

The wildcat well owned by Pure Oil Company is a natural gas producer and was drilled to 17,051 ft. It produces from the Frio sandstone in zone from 16,132 to 16,264 ft. Location is 10 miles west of Galveston, Texas in the Gulf Coast.

The well, Houston Farms Development Company No. 1, flowed at the rate of 1,540,000 cu ft of gas daily through a ⅛-in. choke. It also produced 35 bbl daily of 50.7 deg gravity natural gas condensate and 69 bbl of water.

Extremely high pressures were encountered. Flowing pressure was 5084 psi, and surface shut-in pressure was 9300 psi. The well is centered in a 1346-acre lease.

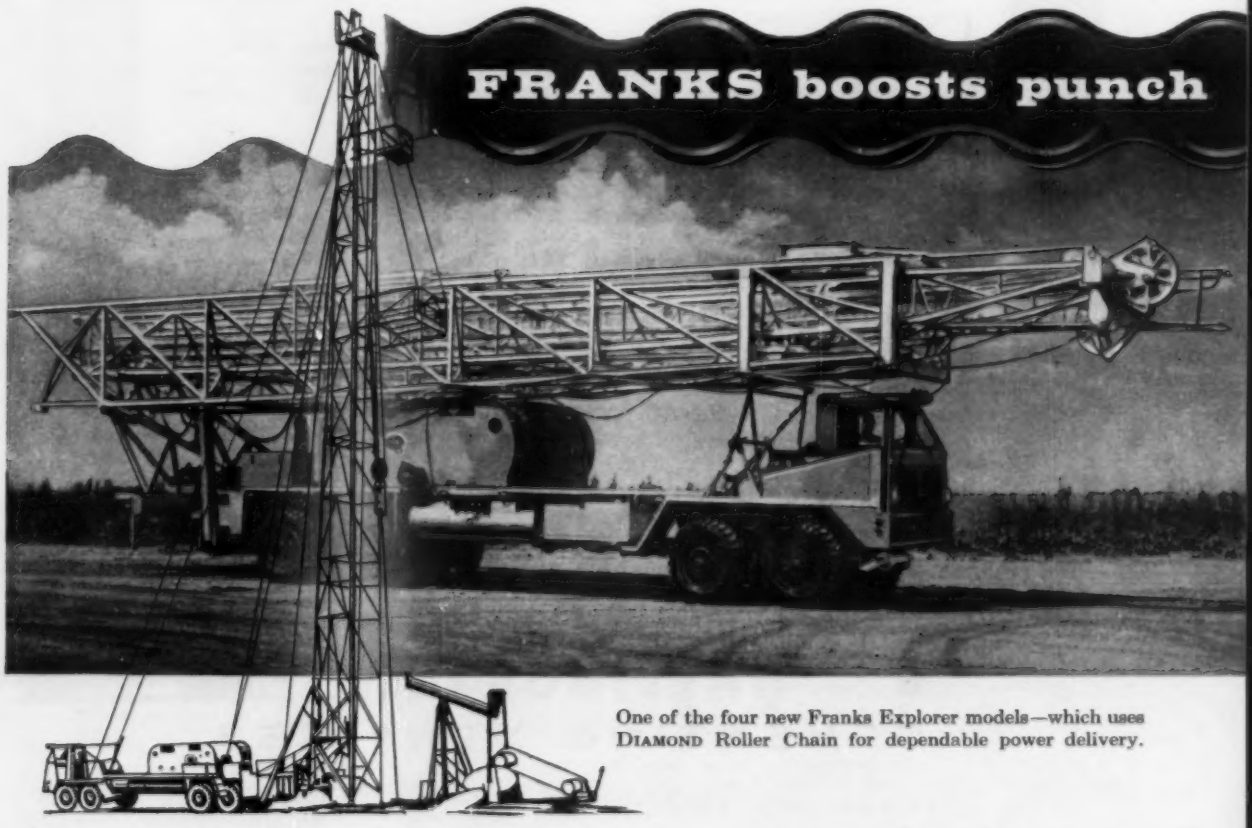
Previously the production depth record in Texas was a 15,000-ft gas well in the Puckett field of Pecos County. The Pure well is the fourth deepest producer in the U. S. The deepest is an oil well in the South Louisiana, brought in at 21,443 ft in 1956.

White Eagle International, Rotary Engineering, Merge

White Eagle International Oil Company of Tulsa, Oklahoma, and Rotary Engineering Company of Midland, Texas have merged. Rotary Engineering will become a wholly-owned subsidiary of White Eagle International, the company presidents announced.

The combined operation will headquarter in Midland and will have assets exceeding $4,000,000 in book value and annual revenues of more than $1,000,000.

Rotary Engineering will continue to operate as a subsidiary under its present name and organization, and received 987,000 shares of White Eagle



One of the four new Franks Explorer models—which uses DIAMOND Roller Chain for dependable power delivery.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

stock for its assets.

White Eagle International's operations include foreign and domestic oil holdings and the company has more than 3000 shareholders.

Rotary Engineering is in the well logging service industry in the United States and abroad, and it offers comprehensive geological and engineering consulting services.

In the new White Eagle International organization, W. H. Helmerich is chairman of the board, Olin R. Prather is president, and James R. Griffiths is vice president. They operate from Midland, and Fred Douglas, vice president, is headquartered in South America.

Pan American Operates 12 LACT Units in Wyoming

Pan American Petroleum Corporation now has 12 lease automatic custody transfer units (LACT) operating at Wyoming's largest oil producing field. They automatically measure, sample, record the temperature, and run oil to the pipeline carrier.

The Elk Basin field LACT installation is one of the largest of its type in operation today, handling an average of about 60,000 bbl of oil daily.

Pan American, Elk Basin field unit operator, installed the first LACT unit at Elk Basin in 1957. It was a custom-built, dump-tank unit. Soon after, a second LACT unit was installed, and it was the positive displacement meter type.

After extensive testing of the two units, 10 additional LACT units were installed, and all Elk Basin field production except that from the Frontier Sand unit was handled by LACT.

Experience gained from the original units contributed to the rapid acceptance by the pipeline company of the final 10 units. An average of 10 months was required from the time of installation until the pipeline company accepted the first two units.

All 10 of the remaining units wents into full time operation almost immediately after their installation.

Remote Systems Prevent Freezing of Offshore Gas

Two remote high-pressure, hydrate-inhibitor injection systems, designed to prevent freezing in the flow lines of offshore gas wells, have been placed in operation by Shell Oil Company in Block 889 and Kain near Mustang Island, Texas.

The sale of gas from the two fields was the first gas production from offshore locations in the area, and it is the first time Shell has used this system on offshore wells.

Glycol, the hydrate inhibitor used, is pumped 4.5 miles from production facilities on Mustang Island. The fluid flows through a 1.5-in. line and is injected into the flow line at the wellhead at high pressure.

Gas flows through a 3-in. line and is processed through a cold-bottom, low-temperature separator with stabilization.

The production facilities were designed for higher liquid recovery, better control of product vapor, and more dependable operation during the winter months. Should glycol be lost while flowing to the wellhead, the well is automatically shut-in.

At the Kain field installation off Matagorda Peninsula, glycol is recovered from the liquid during processing and can be used again in the system. Shell had previously used low-temperature facilities located on the platforms of offshore wells, which required daily attention.

At the Kain field installation off Matagorda Peninsula, a similar system is being used to produce two wells, state tract 487-1, and state tract 488-1, which are located one mile offshore.

The two systems operate similarly, except that methanol instead of glycol is being injected into the flow line at the wellhead in the Kain field.

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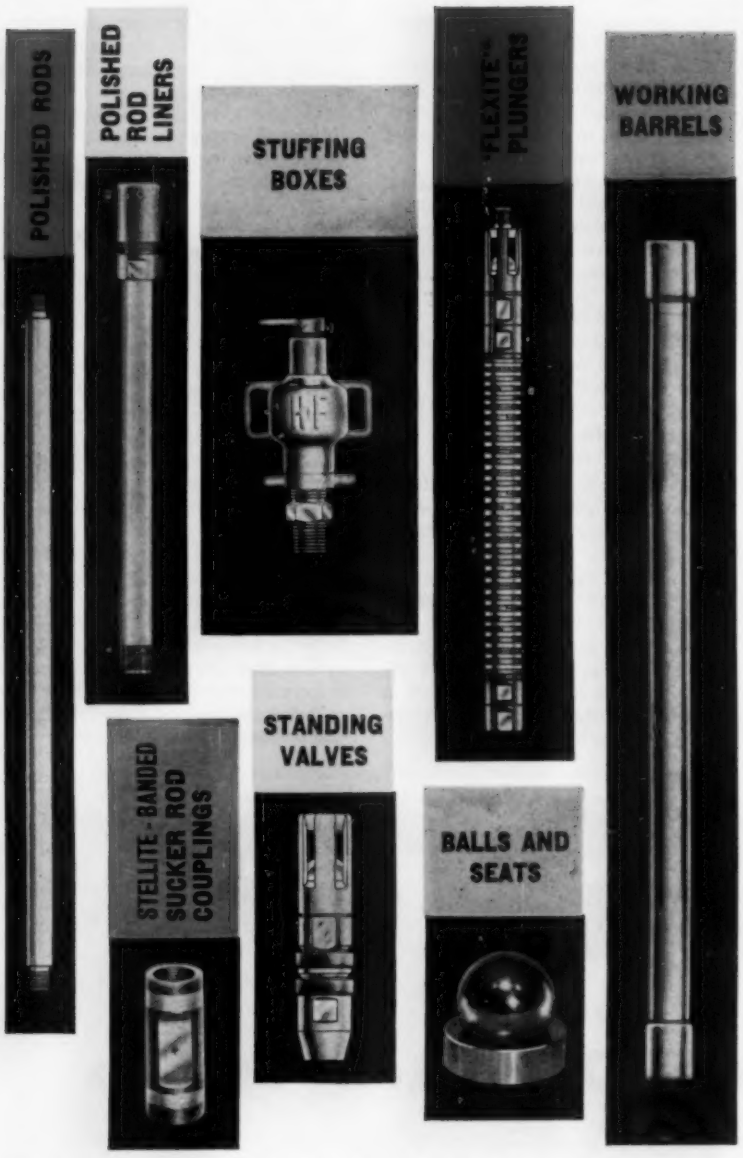

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Drilling

Richfield Spuds Test In Southeast Alaska

Richfield Oil Corporation has spudded in its initial test well in the Katalla-Yakataga area of Southeast Alaska ahead of its contract deadline after five months of preparatory effort and expenditure of approximately $1,500,000.

The Kaliakh Number One well is currently being drilled below 2000 ft, and it is located three miles north and 18 miles west of the Yakataga Federal Aviation Agency station.

The development contract with the department of the interior covers 489,622 acres along the coast of the Gulf of Alaska, east of the Copper River and west of Icy Bay. The federal government recently approved a second development contract with Richfield covering 571,121 acres adjoining the area covered by the first contract.

Preparation began early last summer when the drilling rig and other equipment were loaded onto landing ships for transport to Alaska. The equipment was hauled to the Icy Bay FAA station and landed on the beach.

A road was built 23 miles to the drill site, and completion of the road required building bridges across two major rivers in an area where average annual precipitation reaches about 120 in.

Falcon Seaboard Notes Best Year in History

A 4-percent stock dividend declared by the board of directors of Falcon Seaboard Drilling Company, Tulsa, signals 1959 as the most successful in the company's history, concerning both oil and gas production and drilling income.

The board of directors said that the decision to pay the stock dividend rather than a cash dividend was because of the company's continued policy of utilizing its cash earnings for expansion and development. "The company has recently discovered additional gas reserves in the Panhandle area of Texas," said T. N. Law, company president, "and due to this development we feel sure we will develop additional gas reserves this coming year."

Average daily production of oil for the 10-month period ending October 31 was 1806 bbl compared to 1567 bbl for the same period in 1958. Average natural gas production during the same 10-month period was 5,859,000 cu ft compared to 4,141,000 cu ft for the same period in 1958.

At present, Falcon Seaboard is operating 28 domestic drilling rigs, two more than operated during the same period last year, and nine rigs in their foreign activities maintained in Venezuela and Bolivia.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

General Sales Meeting of Cabot Shops

A GENERAL sales meeting of all Cabot Shops, Inc. personnel was held in Pampa, Texas, recently. This is the first time that a combined Cabot-Franks meeting has been held, according to R. A. Baker, vice president and general manager.

Clyde M. Lackey, sales manager, was chairman of the sessions held in the Cabot auditorium. C. C. Simmons, director of sales and service, said that the meeting coordinated the efforts of the pumping unit and servicing unit salesmen in all territories.

J. C. Williams, president of the Association of Oilwell Servicing Contractors and Dr. Charles E. Irvin, sales promotion specialist of the Detroit Diesel Division of General Motors Corp., were special guest speakers.

Shown in photo are: (front row, left to right) Paul Sloanaker; K. M. Lamer; C. C. Simmons, director of sales and service; R. A. Baker, vice president and manager; C. M. Lackey, sales manager; John Leyh; A. J. Rogers; and Vern Alley. (Second row, left to right) Hilmar Heinritz; Roy Grigsby; Don Turner; Jeff Gray; Ralph Dicus; Fred Tinsley; Dave Kelley; Albert Hastings; and Tom Stringer. (Third row, left to right) Al Wagner; John Campbell; Tom Knobloch; Harold Smith; Joe Winter; and C. B. (Bud) Arndt.

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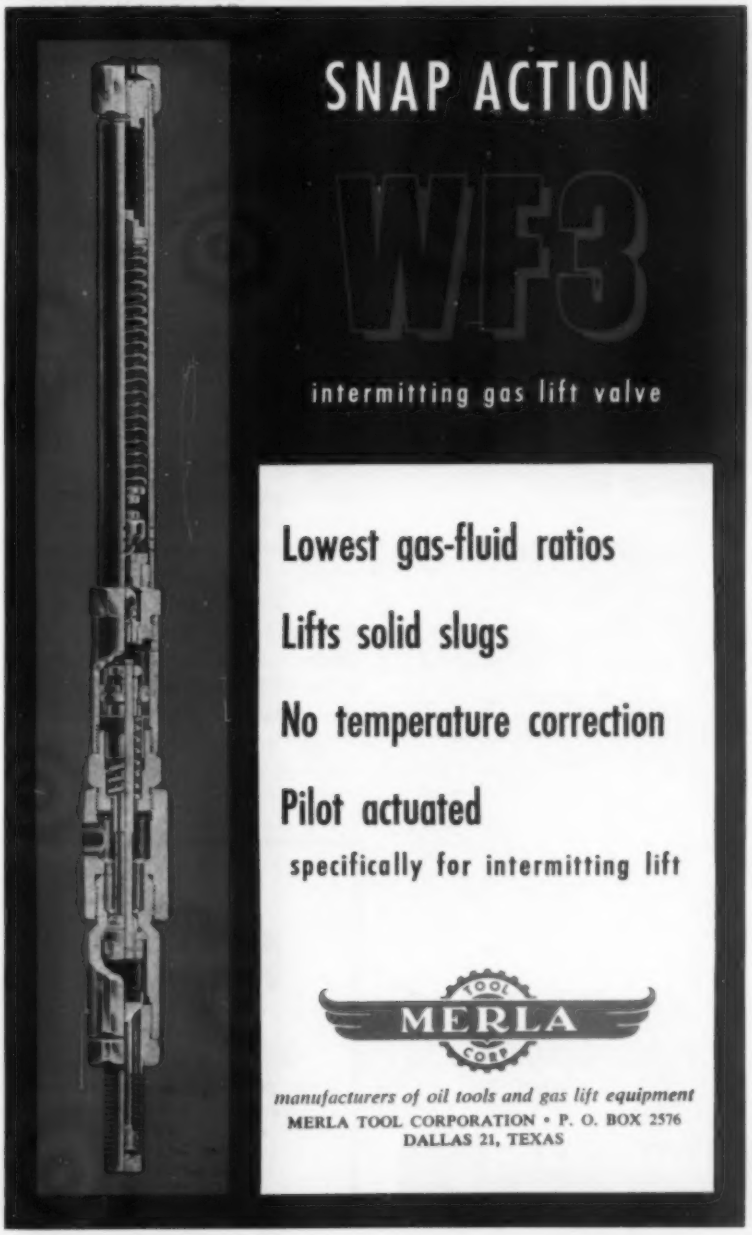

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Dennison Named API Statistician

APPOINTMENT OF William A. Dennison to succeed Fred Van Covern as director of the Department of Statistics of the American Petroleum Institute has been announced by Frank M. Porter, API president.

Dennison, who is now manager of the Economic Research Section of the API's Committee on Public Affairs, assumed his new duties on January 1. He was replaced in his former post by Peter Griskivich, former assistant manager of the section.

Van Covern, who was scheduled to retire on January 1, after more than 35 years with the API, will reach retirement age on March 31. He has, however, agreed to remain for an indefinite period. A native of Brooklyn, Van Covern entered the oil industry in 1917 with the Carter Oil Co. He later transferred to the Foreign Producing Department, Standard Oil Company (New Jersey).

Five years after joining the API in 1924, Van Covern was named director of the Department of Statistics. Among his department's many responsibilities has been the preparation of the Institute's weekly crude oil and refined products output and inventory reports.

Dennison, a native of Ireland, was graduated from Trinity College, Dublin, in 1919. He has a wide background in the field of business economics, and was associated with Standard and Poor's Corp., investment advisors, for 12 years before joining the API in 1943.

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Drilling-Producing Literature

Nuclear Analyzer Shows Hydrogen in Liquids

Total hydrogen determination in liquids to within one percent relative in one minute, using the Model 104 Nuclear Magnetic Resonance (NMR) Analyzer is described in Material Study Report No. 29.58, offered by Schlumberger.

Percent hydrogen by weight in most liquids may be measured quickly and easily by the NMR Analyzer, according to the study. Temperature variations of 10 C have negligible effect.

The report shows the accurate results obtained with n-heptane, gasoline, octane, cyclohexane, ethanol, distilled water, acetone, xylene, n-dimethylformamide, toluene, benzene, tetrachloroethane, and chloroform.

Steps in sample preparation and NMR testing are given, together with calibration curves. *Schlumberger Well Surveying Corporation, Ridgefield Instrumentation Division.*

Circle number (22) on reply card.

Packaged Compressors

A new 8-page bulletin describing the construction and operating features of Cooper-Bessemer AM/2 and AM/4 packaged compressors for gas gathering is available.

Bulletin 91 discusses the incorporation of large compressor concepts in these compact, heavy-duty units. Construction details are given on both the two-throw type and the four-throw type, covering the complete range from 100 hp up.

A number of types and sizes of compressor cylinders can be furnished for either model, at discharge pressures up to 6000 psi. *Cooper-Bessemer Corporation.*

Circle number (23) on reply card.

Valve Brochure Available in Spanish

A new brochure printed in Spanish on Harrisburg's Resilient Seal Valve is now being offered.

This brochure contains a complete description of the valve including a breakdown with pictures and description. Specifications, sizes, and a list of parts are also shown. *Harrisburg Inc.*

Circle number (24) on reply card.

Protective Coatings

New Color Horizons is the title of this new 38-page systems catalog just released by Rust-Oleum. Over one year in production, it is believed to be the most comprehensive treatise on rust and corrosion control by protective coatings ever published.

Highlight of the handy, new manual is a system of specially formulated primers and colorful top coatings. Unique gatefold spread unveils 67 actual color standards.

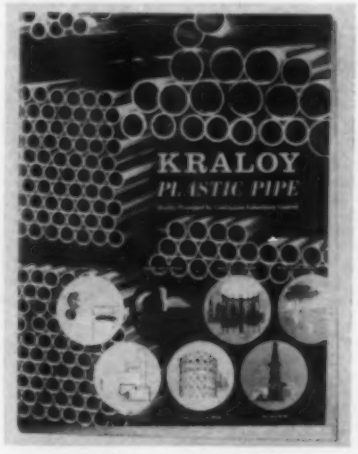
Other important systems described in detail are the water resistant, heat resistant, floor coating, heavy-duty chemical resistant, galvanized metal coating, wire fence roller coating, and the new speedy-dry featuring coatings that dry in less than 30 min.

Easy-to-read technique includes 76 full-color application photos and 110 color chips to show actual colors at a glance. Special technical data section features complete information on surface preparation, types of surfaces, application techniques, how to estimate gallonage needed for various sizes and shapes, glossary of terms, mixing, thinning, and drying information.

The complete catalog is printed in four colors and includes a specially varnished cover for easier handling and added protection. *Rust-Oleum Corporation.*

Circle number (25) on reply card.

Plastic Pipe, Fittings, and Valves



Kraloy Plastic Pipe Co., Inc. of Los Angeles has just published a new free 36-page handbook for engineers which contains pertinent and detailed information on the use of Kraloy PVC plastic pipe, fittings and valves.

Specification, design, and installation information is included as well as a comprehensive corrosion resistance comparison chart for seven types of plastic pipe carrying 162 chemicals.

Other charts show maximum operating pressures for Kraloy PVC pipe at various temperatures, friction loss characteristics of water flow through PVC pipe, and flow of natural gas showing pressure drop in pounds per square inch per 1000 ft of PVC pipe. *Kraloy Plastic Pipe Co.*

Circle number (26) on reply card.

Gravity and Magnetics In Exploration

A new 3-color, 8-page bulletin describing the use of gravity and magnetics in petroleum exploration has been prepared by Geophysical Service Inc. and is available to persons interested in exploration.

The bulletin, GM 59-1, is entitled "GRAVITY-MAGNETICS . . . what they *can* and *can't* do for the explorationist."

Specific examples of gravity-magnetics work and information on the key variables which must be considered in any gravity-magnetics program are discussed. *Geophysical Service, Inc.*

Circle number (27) on reply card.

Motion Control Sheave Bulletin

T. B. Wood's bulletin No. 8102 describes "MCS" variable-speed sheaves with resilient cam-follower design that eliminates freezing and sticking and will hold a constant driven speed under varying torque loads. Patented construction is shown by cutaway photo and diagram.

Tables facilitate the selection of companion sheaves and belts to meet specified drive requirements.

"Sure-Grip" companion sheaves, "Sure-Grip" variable-speed belts and motion-control motor bases are also covered in the 8-page, 2-color, letterhead-size bulletin. *T. B. Wood's Sons Co.*

Circle number (28) on reply card.

Screen Pipe

A new 8-page bulletin with illustrations of all the types of screen pipe manufactured by Emsco Screen Pipe Company is now available.

The bulletin lists all the gages, spacing, and specifications for tubing, line pipe, and casing. Various methods of slotting or drilling, based on specific requirements, are described. *Emsco Screen Pipe Company of Texas, Inc.*

Circle number (29) on reply card.

Branch Connection Fittings

H. K. Porter Company has a new Branch Connection Fitting catalog covering their new complete line of fittings. The catalog, TF-1-59, describes and illustrates the new TeeLets, and the new Fishmouths.

All pertinent design information, sizes, material specifications, and major features are fully described and illustrated. *H. K. Porter Company, Inc.*

Circle number (30) on reply card.

Abrasive Jet Perforating

A development bulletin is available on the Dowell Abrasijet, designed to remove scale and other deposits from the faces of producing formations in wells completed in open hole. It perforates casing without the risk of shattering cement, the company states.

In this service, fluid carrying abrasive particles is pumped at high velocity through small jet orifices. The abrasive action of these particles rapidly cuts through the surface to be perforated or eroded. Water, oil, acid, or similar fluids can be used as the carrying medium.

The abrasive material can be sand, steel pellets, or other materials. Truck-mounted pumps furnish necessary power.

The bulletin describes the tool, shows uses, advantages, laboratory data, field procedures, and case histories. *Dowell, division of Dow Chemical Company.*

Circle number (31) on reply card.

Tool Company Produces Monthly News Sheet

Varel Manufacturing, producers and designers of rotary tools, rock bits and diamond bits are publishing a monthly news sheet called *Varel Views* intended for their customers, dealers and employees throughout the world.

Future issues are to be made available to anyone in the rotary tool field who is interested. *Varel Manufacturing Company.*

Circle number (32) on reply card.

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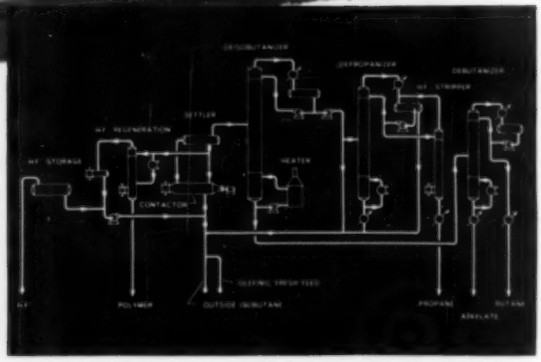
HF Alkylation



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"HF" Alkylation is a catalytic process which combines olefins such as propylene, butylenes and amylenes with isoparaffin (usually isobutane) to form a mixture of branched chain hydrocarbons of higher molecular weight known as alkylate. "HF" Alkylation is also widely used for producing high octane aviation gasoline.

Motor alkylate, an isoparaffin fuel component, burns with a minimum of carbon deposits even in today's modern high compression automobile engines and thus greatly reduces surface ignition and its consequent "rumble."

Another method for producing alkylate is also available to refiners through UOP. It is similar to the "HF" method but uses sulfuric acid as the catalyst. This process is licensed by Universal Oil Products Company under their own patent rights and the patent rights of Shell Oil Company, The Texas Company, The British Petroleum Company, Limited and Standard Oil Company of New Jersey.

These processes for producing alkylate afford further evidence of UOP's policy of providing the refining industry with every means for a well-rounded, profitable manufacturing operation.

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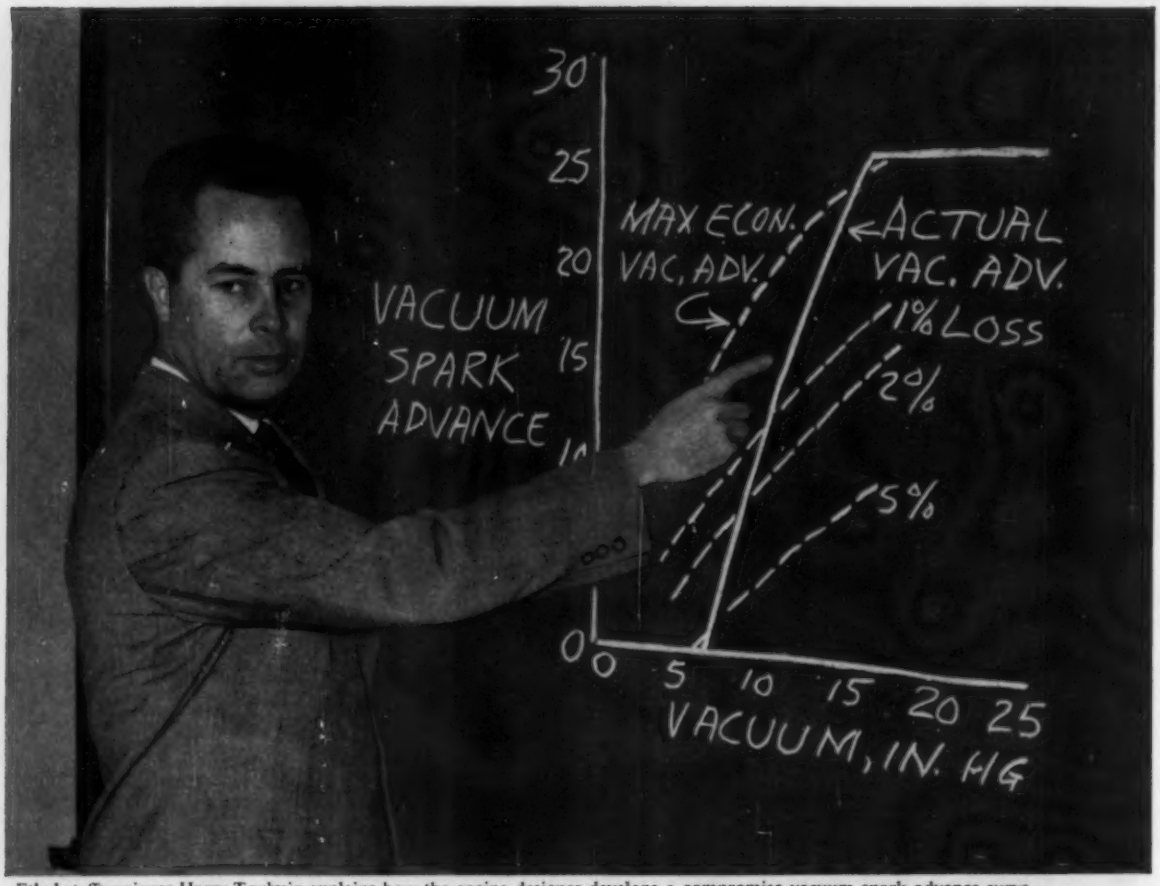


Ethyl staff engineer Harry Toulmin explains how the engine designer develops a compromise vacuum spark advance curve.

Ethyl Research Studies Part-Throttle Knock

What causes it. How to control it.

DURING the past several years, knocking complaints have been recorded for certain premium-fuel-requirement passenger cars at part-throttle as well as full-throttle conditions.

Part-throttle knocking generally occurs at a point between full-throttle and road load, usually at low engine speed and from 8 to 14 inches manifold vacuum. Studies have shown that these conditions are frequently duplicated by the average motorist when operating his car in city traffic at low engine speeds.

Fuel Quality can control Part-Throttle Knock

When the problem of part-throttle knock becomes apparent in a particular car series through customer complaint, the difficulty can be relieved by increasing the Motor octane of the fuel or by adjusting the basic spark advance of the vehicle. A change in fuel quality would be more desirable since this retains top engine performance and maximum fuel economy.

What causes Part-Throttle Knock?

When the engine designer develops a new passenger car engine, a number of compromises are made to obtain optimum performance and durability for a given cost, weight and fuel requirement. One compromise is in the ignition advance curve. The full-throttle advance curve is usually retarded from maximum power by 1 or 2 percent in the mid-speed range.

This yields optimum engine power for a given octane requirement. By taking this small initial power loss, the octane requirement is reduced sharply—2.5 to 4 octane numbers. This establishes a full-throttle requirement for the engine.

To improve fuel economy at road load and between road load and full throttle, a vacuum advance unit is usually added to the distributor. This provides additional spark advance which adds to centrifugal advance at light engine loads. The spark advance curve cannot be set for optimum economy across the entire part-throttle

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

range without increasing requirement excessively. So a compromise curve is used which gives the best economy without part-throttle knocking problems on typical motor fuels. If not enough compromise is made, the vehicle will be part-throttle knock limited.

Octane number requirement for such a vehicle is shown in the figure to the right. With sensitive reference fuel, octane requirement peaks at manifold vacuum of about 12″—and is a number higher than at full throttle. This is due to severe depreciation of sensitive fuels (those having large differences between Research and Motor octane) at light loads. Under these conditions, carburetor mixtures are leaner, mixture temperatures higher and exhaust gas dilution is greater—all of which contribute to the depreciation of the sensitive fuel.

Motor Octane is the Key

Since low sensitivity fuels are depreciated less than high sensitivity fuels, the part-throttle knocking problem is relieved by increasing the Motor octane number. This was substantiated recently in the Ethyl 1959 Premium Gasoline Antiknock Behavior study.

Road antiknock performance data were obtained on 30 premium fuels in five 1959 passenger cars. In addition, data were obtained in seven cars on two special sets of fuels, one with constant Research octane number and one with constant Motor octane number.

Both of these studies indicated that the most important fuel factor in controlling part-throttle knock is Motor octane number. In the low-speed range where most part-throttle knock occurs, Motor octane number has effectiveness of approximately unity, but Research octane has little or no effect on road octane number.

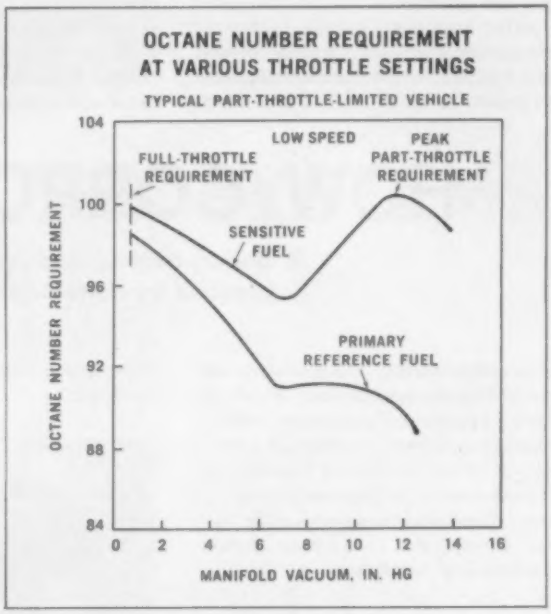
Fuel hydrocarbon composition has very little effect on road performance at low speed. In the high speed range (3000 rpm) an increase in Motor octane number of one unit will increase the road rating by two units, while an increase in Research octane number will actually decrease the road rating. At 3000 rpm an increase in aromatic content and a decrease in olefin content will increase the part-throttle road rating of a fuel.

Control by Engine Adjustment— A loss in economy

An obvious way to correct part-throttle knock is to reduce the spark advance at part throttle. This defeats the original purpose of the manufacturer since it reduces operating economy in this driving range.

A recent study showed that approximately 40 percent of the tank fuel is consumed in the 5″ to 15″ manifold vacuum range under some commuter driving conditions.

Further, a reduction of part-throttle spark advance can change the part-throttle response (acceleration) of a car, causing flat spots. This, in turn, can be corrected by enriching the mixture—a further loss of economy.



How Ethyl Research can help you

For a detailed discussion of part-throttle knock, ask your Ethyl Representative for copies of the Ethyl research paper, "Part-Throttle Knock," presented at the SAE National Fuels and Lubricants Meeting in Chicago, October 28-30, 1959.

Additional information on the subject of part-throttle knock can also be found in the Ethyl report entitled, "1959 Premium Gasoline Antiknock Behavior." Your Ethyl Representative will be glad to supply you with copies, or arrange for a presentation of this major project by an Ethyl Refinery Technologist.

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HELPFUL WATER CONDITIONING DATA FROM BETZ

HOW CORROSION ATTACKS

■ Boiler, cooling and process water systems are constantly plagued by corrosion. This article tells how and why.

CORROSION can be defined as the destruction of a metal by chemical or electrochemical reaction by its environment. In the corrosion of ferrous metals in contact with moisture, reversion of the metal to the oxide form takes place. The driving force or the tendency to corrode is electrochemical. However, the rate at which corrosion proceeds is largely dependent on the resistance to continued attack by the products of the corrosion reaction.

In industrial water systems, the principal factors influencing corrosion of ferrous metals are the water characteristics, temperature, rate of flow and the contact of dissimilar metals. The chief variables controlling the characteristics of a water are its dissolved oxygen content, carbon dioxide concentration, pH and dissolved solids. Other factors are involved, of course, such as the possible presence of free mineral acid, hydrogen sulfide, sulfur dioxide, etc. In addition, certain bacteria may be a factor.

Dissolved Oxygen

The presence of oxygen is usually essential for serious corrosion to take place in natural waters. Dissolved oxygen will greatly accelerate corrosion in acid, neutral, or slightly alkaline waters.

The corrosion of iron in pure water in the presence of oxygen may be expressed in a simplified way by the following equations:

(a) Fe (iron metal) $+ 2H^+$ (hydrogen ion) $\rightleftarrows Fe^{++}$ (ferrous ion) $+ 2H^\circ$ (hydrogen atoms)

This is the typical primary reaction, in which iron enters the solution as ferrous ions, and hydrogen ions take up the charge and plate out as hydrogen atoms and thus maintain the system electrically neutral. This primary reaction is followed by either the destruction of the film of hydrogen by reacting with dissolved oxygen:

(b) $2H^\circ$ (hydrogen atoms) $+ \frac{1}{2}O_2$ (dissolved oxygen) $\rightarrow H_2O$ (water)

or the hydrogen can be removed as bubbles of gas:

(c) $2H^\circ$ (hydrogen atoms) $\rightarrow H_2$ (hydrogen gas)

Reactions (b) or (c) must take place in order to permit reaction (a) to proceed. Otherwise, the presence of the hydrogen film obstructs further progress of the primary reaction either by insulating the iron from the solution or by the increasing tendency of the hydrogen in the film as it is built up, to re-enter the solution and thus oppose the corrosion tendency.

In natural waters containing dissolved oxygen, reaction (b) is the controlling factor and corrosion is almost directly proportional to the oxygen content of the water.

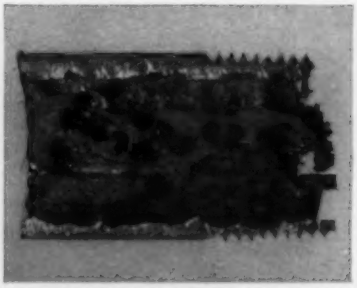

Figure 1 — Section of line showing pitting by dissolved oxygen.

The hydrogen ion in reaction (a) is available from ionization of water as follows:

(d) $2H_2O$ (water) $\rightleftarrows 2H^+$ (hydrogen ions) $+ 2OH^-$ (hydroxyl ions)

When hydrogen is plated out, the hydroxyl ions remaining cause an increase in the alkalinity adjacent to the point of corrosion. The ferrous ions entering solution will tend to precipitate as ferrous hydroxide. In the presence of dissolved oxygen, the ferrous ions will be oxidized to ferric hydroxide. Depending on the supply of oxygen, the resulting corrosion products will usually consist of black or green ferrous hydroxide next to the metal and reddish-brown ferric hydroxide which forms the outer layer, with graded mixtures of the two in between. The initial rate of corrosion is usually much greater than the rate after a longer period of time due to barriers set-up by the reaction products.

pH

At a pH below 4.3 (the region of free mineral acidity) the chief controlling factor in promoting corrosion is pH and the hydrogen film is removed by hydrogen evolution as shown by reaction (c). In the free mineral acid range the ferrous ions entering solution will remain soluble and therefore no insoluble reaction product will result. In the absence of a barrier the corrosion rate in acid solutions is therefore rapid. When the solution contains dissolved oxygen in addition to a pH value in the free mineral acid range, the rate of corrosion is further accelerated.

At a pH above approximately 9.5, as the alkalinity increases the pH or hydrogen ion activity decreases and the primary reaction as illustrated by equation (a) is slowed down. The rust coating formed in alkaline solutions is a more protective barrier than the one formed in neutral solutions. Therefore, the rate of corrosion is appreciably decreased and in fact in an alkaline solution, a negligible amount of corrosion will take place at normal temperatures and in the absence of dissolved oxygen. However, in the presence of dissolved oxygen, reaction (b) will still be controlling and while the rate of corrosion will be appreciably decreased a serious amount can still result.

At a pH between these limits (4.3—9.5) the presence of dissolved oxygen plays a more important role than the pH.

Dissolved Solids

In general, increase in dissolved solids content of a water increases the corrosivity. The electrolytic theory views the corrosion mechanism as an electrolytic cell. The iron metal provides both the anode and the cathode of the cell and the water is the electrolyte. At the anode,

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the metal dissolves in the water, and in so doing it gives up two electrons which flow through the metal to the cathode where the electrons combine with the hydrogen ion to plate out hydrogen atoms as a film on the cathode. Various explanations have been advanced for the corrosive effect of higher dissolved solids. Higher dissolved solids increase the conductivity of the water thus favoring corrosion. One logical theory involves the effect of ions in destroying or altering the coating of corrosion products on the metal. A loose non-adherent coating under ordinary conditions may accelerate the rate of corrosion locally and produce a pitting condition, whereas a uniform, adherent coating may form an effective barrier and reduce the corrosion rate considerably. The chloride ion in particular exerts an adverse effect and within certain limits of concentration permits accelerated attack.

tact of dissimilar metals is known as galvanic action. The tendency of a metal to dissolve and enter solution as an ion is measured by the electrode potential between the metal and its ions. The listing of the electrode potential of the various metals constitutes the familiar

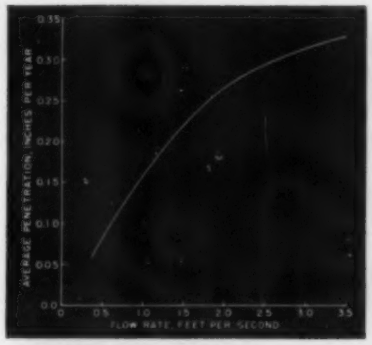

Figure 2—Influence of flow rate on corrosion.

ferrous bicarbonate, tends to elevate the pH and as the pH increases above 5.9, the reaction rate becomes reduced. The hydrogen formed in the reaction will also have a retarding effect particularly when the pH exceeds 5.9. The ferrous bicarbonate formed in the reaction is soluble and can be carried along with the condensate. When dissolved oxygen is also present, it will accelerate the rate of corrosion by removing the hydrogen to form water.

Other Factors

Corrosion of ferrous metals in the presence of moisture is a complex subject. Many other variables will affect the corrosion rate, such as homogeneity of the metal, condition of the metal surface, ratio of surface areas exposed by two dissimilar metals, static and cyclic stresses, oxygen concentration cells, etc.

INDUSTRIAL WATER SYSTEMS

Temperature

The chemical reactions of corrosion increase in rate with increase in temperature. Increased temperature decreases water viscosity and thus increases the diffusion rate of oxygen. Electrical conductivity is increased at higher temperatures, thus producing an effect similar to increase in dissolved solids. Pitting may be enhanced where adjacent metal areas vary in temperature, with the hotter sections anodic (more corrosive) to the colder areas.

Flow Rate

Increase in the rate of flow tends to increase the corrosion rate. Figure 2 illustrates data secured through the exposure of ¼" tubular low carbon steel specimens to Philadelphia (Delaware supply) tap water at a temperature of 120 F. The corrosion rate increases rapidly with increase in flow rate although at higher flow rates the influence is less pronounced. The influence of flow rate on corrosion is primarily due to the increase in supply of dissolved oxygen which destroys the hydrogen film in keeping with reaction (b).

Dissimilar Metals

The corrosion that occurs from the contact of dissimilar metals is known as galvanic action. The tendency of a metal to dissolve and enter solution as an ion is measured by the electrode potential between the metal and its ions. The listing of the electrode potential of the various metals constitutes the familiar Electromotive Series. The electrode potential of hydrogen is defined as zero. The metals that are higher in the series are considered able to displace those metals lower in the series.

The Electromotive Series cannot be taken as a precise indication of galvanic action. The potentials of various metals can be altered by ion concentration, temperature and the corrosive environment.

Carbon Dioxide

In a neutral water, taken from surface supplies where dissolved oxygen is present, the presence of carbon dioxide has little effect on the corrosion rate. However, many well waters, which are usually devoid of oxygen, will be found to contain appreciable amounts of carbon dioxide. In steam and condensate systems, it is possible to encounter serious corrosion from carbon dioxide even in the absence of dissolved oxygen.

When carbon dioxide dissolves in water it forms carbonic acid which is a weak acid and produces corrosion in keeping with the following reaction:

(a) $Fe + 2H_2CO_3 \rightarrow Fe(HCO_3)_2 + H_2$

Fe: iron; $2H_2CO_3$: carbonic acid; $Fe(HCO_3)_2$: ferrous bicarbonate; H_2: hydrogen

The above reaction proceeds rapidly at a pH below 5.9. The reaction product, ferrous bicarbonate, tends to elevate the pH and as the pH increases above 5.9, the reaction rate becomes reduced. The hydrogen formed in the reaction will also have a retarding effect particularly when the pH exceeds 5.9. The ferrous bicarbonate formed in the reaction is soluble and can be carried along with the condensate. When dissolved oxygen is also present, it will accelerate the rate of corrosion by removing the hydrogen to form water.

Water characteristics also are influenced by factors such as hydrogen sulfide, chlorine, and biological factors—all of which can accelerate markedly the corrosion rate.

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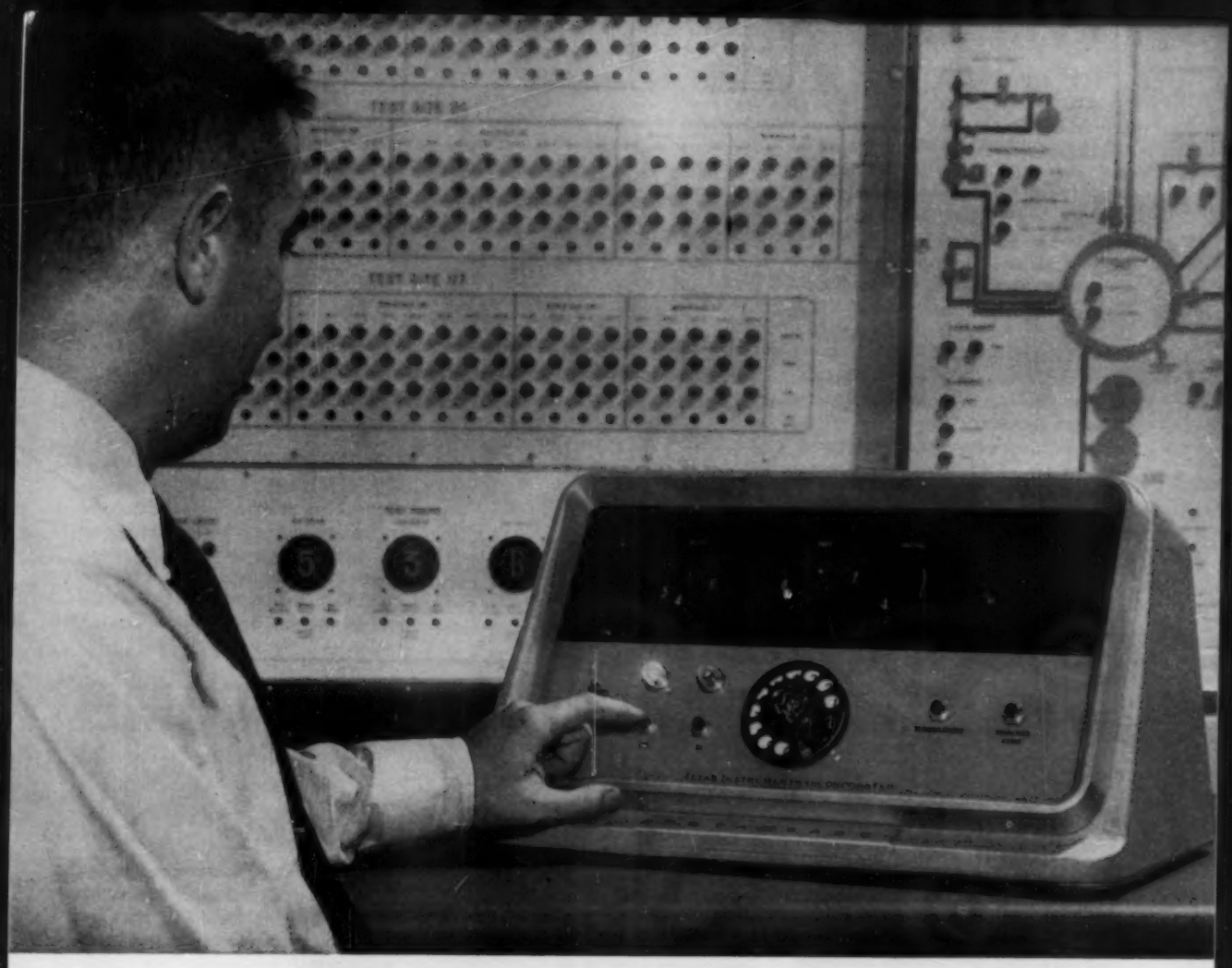

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Despite diligent effort, when . . .

Buying Thermal Process Performance . . .

the giving or receiving of a valid performance guarantee is not readily consummated for a thermal process. The authors discuss the difficulties and offer some concrete recommendations

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MAYBE it started when the first continuous crude still went onstream in 1924. Or that day in 1859 when Colonel Drake pulled the bung on Pennsylvania's unsuspecting underworld. Maybe it even goes back to the time of Aladdin when his suppliers, corralling their camels, dug the posts too deeply in the Kuwait sands. In any case its been a long time since refiners of petroleum products first sought a means for procuring a piece of process performance.

The piece referred to is the **performance guarantee** appended to proposals for turnkey petroleum plants or items of process equipment. Since it is not known when the performance guarantee began, its founder shares equal obscurity . . . doubtless laying beneath some weathered shale, unheralded and forgotten . . . as well he ought to be.

A great deal of time is spent annually by the staffs of refiners and engineers-constructors alike in writing specifications for process facilities and in the negotiations predicated upon them. Parties equipped with and without unhoned axes raise two relevant questions:

(1) Why should a purchaser of refining facilities buy them without a performance guarantee and

(2) Why should a vendor of such facilities include it as a condition of sale?

There is little equivalence in their positions. The refiner has a long period of time in which to realize profits from any deviation in the scheduled return of his investment although he doesn't expand a plant on this theory. The engineers-constructors of the facilities, on the other hand, have but one brief opportunity to translate the refiner's expectations from paper into operation — and then it is cushioned by a very meager margin. If the engineers-constructors have erred in their guarantee in any way such that even a minor financial or service adjustment must be made, it mainly comes out of their small profit. One or two such projects can erase any hope of a profitable yearly statement.

However, the preponderance of funds expended on capital facilities are permitted to change hands only when accompanied by a performance guarantee. This reflects the stronger position of the organization spending the money. Warrantees against defective workmanship or materials are excluded from consideration since these are generally resolved rather simply in the pervading atmosphere of good humor, sportsmanship and a penchant for togetherness.

No objection is intended relative to the performance guarantee, since it is so well established in our mores, except that it seldom provides the protection which either party expected of it. In an effort to achieve sufficient understanding between purchasers and vendors, certain smudged concepts have been incorporated into performance guarantee contracts which have possibly retarded some of the engineering attainments of the refining industry as a whole.

Consider the negotiations for the purchase of a still and its auxiliaries for the purpose of performing a given separation. Some parts of the assembly can be guaranteed by conventional design practices and others cannot. Yet it is a common practice to call for a performance guarantee or to offer one relative to the process as a complete entity even though some component stages of the process are incapable of a performance guarantee. The entire manufacturing sequence of the process is thus imperiled although it can be confined to a partial risk and a non-recuperable liability by an allowance for contingencies.

It happens every day: Engineers-constructors issue guarantees on complete plants without receiving equivalent guarantees on the component parts. The component parts in turn become the property of the refiner when the plant is completed. Fortunately this loose procedure has proved more convenient for both the purchaser and vendor than the ultimate resolution of the problem. It attests to the high order of performance of engineers-constructors and the reasonable attitude of the refiners whom they serve.

The aspects of the transaction which can be stated in

terms of a guarantee are by no means fragile. Barring the implausible, such as a separation guarantee which contravenes equilibrium relationships, and given a range of feeds, it is possible to write qualitatively and quantitively product separation specifications possessing sharp teeth. However, it often happens that the feed stock changes beyond any anticipated range between the time the contract was let and the time the equipment was placed onstream. What happens then?

While the computer facilitates calculation of the anticipated end-products for a rather large variety of changes, the engineers-constructors derive their income from the movement and erection of materials rather than the continuing operation of a computer. Under many circumstances sufficient ranges of variation can be incorporated into specifications and the performance guarantee predicated upon meeting all of them.

There is considerable legal responsibility in meeting the product specification terms of the contract. The prudent approach often receives little consideration since it includes the conditions which will ensue in the event that the performance guarantee is not met. It is an ugly thought but it does represent half of the two possibilities. Yet no one wishes to be associated with a $10 million project which *possibly* might not perform and so the terms for adjusting possible deficiencies are rarely detailed in the contract.

When a 50 percent partnership is contemplated the need for the partners to obtain a formal agreement often seems a superfluity. Mutual esteem, admiration and aggressiveness are at a high level and a handshake by the prospective partners appears to provide adequate assurance of personal dedication. It really can be as simple as that at the start of most ventures, personal or corporate.

But what happens later on when the partners become disenchanted with the venture or each other — and the esteem, admiration and aggressiveness have lost some of their ardor or mutuality? How do they part advantageously without destroying the net worth they have worked to build? Who gets what? This is one of the real possibilities which must be anticipated in their formal agreement.

So it is when a $10 million facility goes onstream and can only produce a fraction of its rated capacity. It often takes considerable time until the form and demand of the representations are figured out. This is the positive aspect of omitting the modus operandi for the eventuality. The casual atmosphere which accompanies the first communication that two or three millions of productive facilities have failed to arrive with the remainder of the plant is beneficial to the ensuing conversations. It stems from the fact that the refiner temporarily has no need for total capacity. However, if the refiner has sold the total rated capacity of the new facility before it is abuilding, the cordiality is omitted and the representations acquire considerable vigor.

The guaranteed quantities of the utilities are also strongly enforceable along with dimensions, makes and models of the components. But what if utilities have been underestimated? A large physical plant has been built which is capable of production, perhaps not quite as planned — but by how much? Also enforceable is one of the most sinister quantities of all — the guaranteed pressure drop. Few raps are as hard to beat as the over-committed ΔP in towers, reactors, piping or heat transfer equipment.

No Guarantee

To examine the non-guaranteeable aspect of thermal process plants return to the purchase of the guaranteed separation. The facility may produce the specified product with suitable quality, but insufficient quantity. Exclusive of controls, hold-up and piping the discrepancy might result from either of two main causes: (1) The column may not have adequate trays or through-put, or (2) the apparatuses for introducing and removing heat may be inadequate. If the column has too little diameter, bubble-cap slot area, tray submergence, or too few trays, it can be recognized rather readily by simple, uncontrovertible measurements.

"Impossible to Prove"

If the discrepancy is due to the heat transfer apparatuses associated with the process, the current computations employed by the petroleum industry make it well nigh impossible to prove the failure to comply with the thermal performance guarantee of an individual component. A guarantee on a plant facility as a whole should be no stronger than its weakest link. But under the duress of competition, strange things happen and high among these is the assumption of risks by both the purchaser and vendor greatly exceeding any component assurances they receive.

Now focus upon the unenforceable link in thermal performance, namely the heat transfer equipment and the means by which it is contracted or subcontracted. The usual equipment specifications and guarantee will rely upon all or several of five major publications. The authors of the publications spent a great deal of time in their preparation and knew what they were doing and why. However, in preparing such works for broad distribution and application there is always the onus of being general and of anticipating all manner of happenings in the future.

The five publications referred to are: (1) The ASME Code for Unfired Pressure Vessels,[1] (2) the ASTM or ASME Code for Material Specifications,[2] (3) the Standards of the Tubular Exchanger Manufacturers Association,[3] and (4) the Equipment Test Procedures[4] established by the AIChE and (5) the Power Test Codes[5] of the ASME.

In those states in which the **ASME Code for Unfired Pressure Vessels** is enacted directly or indirectly into law, it is a powerful tool, particularly with regard to criminal negligence in application or design.

However, there are certain discretionary facets to the code and a piece of equipment such as a heat exchanger cannot truly be built in accordance with the Unfired Pressure Vessels provisions of the ASME Code. The code provides for the integrity only of the containment vessel which houses both streams such that it will not disintegrate under the combined effects of temperature or pressure for which the vessel was designed and stamped.

The shell of an exchanger can be designed to accommodate a low pressure fluid while the tubes are designed to accommodate a high pressure fluid. If channels are externally exposed, they are designed independently of the shell fluid. The integrity of the shell need only maintain for those conditions covered by the shell side specifications. If a tube carrying the high temperature fluid should rupture, it is the responsibility on installation to assure adequate pressure relief to avoid any elevation of the shell beyond its design pressure.

Ordinarily, and in the absence of corrodents, the escape of a flowing high pressure stream into a flowing, check-valved low pressure stream is not serious since it merely accelerates the low pressure stream in the direction of flow. It may be locally serious, however, when the fluids are pressurized but one or both are not flowing because of some unanticipated flow interruption. **This is where accidents occur.** A flowing petroleum residue at 400 F could quickly convert a simple cooler into a steam boiler if the water flow were halted and relief were predicated on water rather than steam effluent.

Normally, weird occurrences can be guarded against inexpensively by allowing only a restrained fractional difference between the design pressures of the high pressure and low pressure streams. Whatever the design pressure of the

high pressure stream, the design pressure of the low pressure stream is not permitted to be less than two-thirds or three-quarters of the design pressure of the high pressure stream. An exception arises in the case of very high pressures where the fluid is independently confined to the tubes and the shell operates at a much lower pressure.

ASME Material Specifications generally assure the strength characteristics of metals and alloys so that repetitive communication can exist between the purchaser of equipment, the vendor of the equipment, and the vendors' suppliers of materials.

All too often in the desire to achieve longevity, the ASME Material Specifications are given significance with regard to corrosion resistance. A stainless steel possessing a particular identification number is assumed to be passive to certain corrodents and becomes traditionally identified with particular services. Then, at perhaps some later time, a lot of tubes or a piece of plate fails in a common service in which there is no record of a similar previous failure.

Material Specifications do not guarantee corrosion resistance nor are the latitudes of chemical and physical analyses which assure consistent strength in any way related to tolerable latitudes of corrosion resistance. A stainless steel may be just as strong at either end of an allowable range of 16 to 18 percent chromium. However, the ability of the stainless steel to resist chemical attack may be vitally different at both extremities of the chromium analysis.

Standards of the Tubular Exchanger Manufacturer's Association have made considerable contributions through the years to the establishment of uniform design practices. This is particularly true with regard to the mechanical design elements which are not included in the ASME Code. They do not conflict with the ASME Unfired Pressure Vessels Code, or the ASME Material Specifications.

TEMA Standards reflect the efforts of a dedicated group of engineers experienced with both the ASME Unfired Pressure Vessels Code and Material Specifications toward improved communication between purchasers and vendors relative to the durability and operation of heat transfer equipment. They are enforceable when included in the contract form for mechanical elements and assembly procedures. They neither presume to be[6] nor contain enforceable provisions for thermal performance and only establish civil responsibility. So far, then, it has not been possible to purchase the guaranteed transfer of a single Btu: just some reliable metals well put together.

AIChE Standard Testing Procedures of Heat Exchangers were not intended to serve as a code,[7] but rather for proposing and standardizing various methods for carrying out tests. They entail civil responsibility and are enforceable and definitive with regard to pressure drop. With regard to thermal performance they require the appendage of specific codiciles suggested by the Testing Procedures but not outlined in them.

Tests on heat transfer equipment are not definitive relative to thermal performance because of the fouling factor. Somewhere in the folklore of heat transfer practice the fouling factor was invented as one of several means of providing oversurface in equipment design. Little-by-little this provision for oversurface, necessitated by the accumulation of dirt, came to be regarded as a valid entity in design and performance.

Depositions of dirt on heat transfer surfaces which produce little or no visual increase in pressure drop over a long operating period can severely and rapidly reduce the ability of the surface to transfer heat. The fouling factor, *hr x sq ft x °F/Btu*, has no identification with the progression of time. The *hr* is a unit dimension indicating that every *hr* is alike — there are no plurals in the system. The fouling factor, like the tube wall metal, is just a piece of thermal resistance. Without an identification with time it is nevertheless presumed to be capable of a zero value at zero time and a finite value at finite time. These are fancy mathematical gymnastics which are expected of the fouling factor but which no one expects of the tube wall metal, least of all the manufacturers of tubing. The whole concept should have also augured a new field of differential equations.

The fouling factor does not rely on this simple defection for destroying the opportunities for a valid thermal performance guarantee. First, it is well known[8,9,10] that dirt deposits more rapidly on clean apparatus and in varying quantities depending upon the rate at which a fluid carrying a given concentration of dirt is circulated. These things have been known for a long time, but they have not been subjected to any great amount of definition.

If a performance guarantee is to be predicated upon clean equipment at thermal equilibrium it must be recognized that quite some fluid must flow before equilibrium is attained. In addition, the conditions under which equilibrium is attained are not identical in flow or temperature with those on which the performance was guaranteed. Was it not assumed that there would be zero dirt at zero time with a given flow? During start-up or fractional flow how does one reconcile zero time and zero dirt for the guaranteed clean conditions?

In an extreme case, by the time steady rated flow has been achieved, the apparatus might already be within one-half or two-thirds of its ultimate dirtiness. A program of measurements could be devised for the early unsteady state conditions while the metal became heated and the flow increased from zero to rated load. Under these conditions, it appears unlikely that good heat balances could be obtained without exceptional care and the matter of initial deposition still has not been accounted for in any way other than crowding closer to time zero.

Some waiver could be agreed upon between the purchaser and vendor to cover deposition during the steady or unsteady state operation such that the vendor is allowed the benefit of a given percentage of the ultimate dirt, say within the first 24 hours onstream. But then a time dependent function must be employed and when this happens it is no longer possible to utilize fouling factors.

Another weakening aspect of the fouling factor lies in the lack of association between the definition of what dirt is, the dirt content of a fluid, and its dirt deposition characteristics as reflected by a fixed resistance. Under equivalent flow conditions, tubes carrying mildly scouring slurries often remain operative longer in heat transfer services than others transporting clean overhead products with imperceptible solids contents. Regrettably little is known of the phenomenon of thermal surface fouling and the thickness of a deposition is by no means an invariable criterion.

A purchaser might indicate that fluid is characterized by a 0.002 dirt factor. In addition to not knowing just when a 0.002 hr × sq ft × °F/Btu piece of resistance is supposed to occur there is also no way of knowing that the so-called "0.002" fouling fluid should not really be "0.008." The entire dimension is uncalibrated with regard to any analyzable aspect of dirt. In such a case the indefiniteness of the fluids would also impair any strong conclusion relative to meeting a guarantee except insofar as some abortive deficiency in performance were at hand. In a large facility the object of a test would be to track down every last percent since each percent might easily represent an investment of $100,000 by the refiner.

It is not the objective of this article to explore the foundations of the thermal performance guarantee so much as the advantages to both contracting parties of improving them. The present procedure need not continue indefinitely. The authors have published[11,12] various mathematical deriva-

tions dealing with the subject. They have also developed a method of determining performance guarantees based upon testing only fouled equipment so as to obviate the need for obtaining an experimentally determined zero time-dirt reference. It is hoped that these later derivations can be released in the near future.

Having briefly reviewed the limitations of the performance guarantee, **is there any reason to change procurement procedures?** One can devise any desirable policy for procuring durability and receive a good measure of return for the added investment. Opposed to this quality, however, are the two other aspects of performance discussed above — such as corrosion and thermal guarantee.

Only very rarely is a warranty available against corrosive attack. Usually even the purchaser considers it an unfair request since the vendor cannot control the life history of the equipment while in use. Furthermore, in heat transfer apparatus one of the more formidable types of corrosion is pit-type corrosion of tubes. Only a small quantity of metal need be corroded before both the hot and cold streams intermix and the apparatus must be retubed.

While the tubes may be considered expendable compared with the rest of the apparatus, it seems that a large investment in mechanical durability is often unjustified in corrosive services. On the other hand, if corrosion or erosion are of no consequence there is little reason to restrict the anticipated life period of the apparatus by skimping on a few parts.

The anticipated life cycle of a process can be determined as a probability so that the components approach uselessness economically at about the same time the process itself becomes obsolete. The development of design equations based on this concept have fascinating implications matching those of the non-fouling plant already published by the authors.

With regard to obtaining a thermal performance guarantee, until the new techniques become publicized and accepted the best practice still appears to be the check and double-check by purchaser and vendor. The corroboration of computations clarifies immeasurably the expectations of both the purchaser and vendor. This, of course, if the strongest force in promoting mutual understanding and getting the appropriate equipment in the right place at the right time. Nobody wants to participate in the creation of a dud and it can be just as costly to both the purchaser and vendor.

A second important point is to recognize that a performance deficiency is always possible in new types of plants and equipment or with regard to new applications. Some forethought on this matter will often enable a satisfied result to be obtained in the shortest period of time at the least expense. It only entails consideration for three major points — product quality, product quantity and operating costs.

Stories do get around about various deficiencies in plant and equipment performance and unusual demands for their amelioration. Most everyone is aware of some of them. But just as many of the exotic tales have origins founded in mythology rather than reality. In the most common case a vendor makes an adjustment which he is not obligated to perform under any reasonable interpretation of his contract. **He does it solely to maintain a healthy atmosphere for future business with his customer.**

Recognizing the limitations, the best assurance that a plant will go onstream satisfactorily and on time lies in the reputation of the vendor in these regards. Being a human and multiple-faceted complex, the vendor cannot be expected to perform with complete uniformity time-after-time. Occasionally he may be particularly pressed by simultaneous, unanticipated demands on his staff or in his ability to procure materials and services. Fortunately it is almost impossible to go wrong in this respect since project, process and design engineers possess incredibly high standards of loyalty and integrity.

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Acknowledgment

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Here are the answers to three questions regarding specifications . . .

Why, Who and How to Specify Centrifugal Compressors

The fundamental principle behind any procurement specification is maximum return on the purchaser's invested capital

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FIFTEEN YEARS AGO, the number of centrifugal gas compressors in operation in process plants was small. The centrifugal air compressor had long since displaced positive displacement blowers in large capacity applications such as blast furnace blowing in the steel industry. Lack of application in process plants was a result of many factors. Positive displacement gas compressors were paralleled to handle gas compression loads due to compressor size limitations but users rationalized this arrangement on the basis of flexibility and "covered" equipment outage periods by including a spare unit in the installation. If a single centrifugal gas compressor had been installed, a full size spare unit would have been thought necessary. Gases to be compressed were often other than air and some users were unwilling to experiment with performance and sealing equipment. The manufacturers had little to offer and the users little confidence in something they had not used.

Today the picture has changed. Users are no longer willing to employ multiple units including a spare if a single centrifugal compressor will do the job so well that no spare is required. As always, pioneers show the way and today there need be little concern regarding performance. The manufacturers and the pioneer users have worked hard. Now a centrifugal gas compressor is available for almost any gas compressor application. Users are hearing of successful applications and are specifying centrifugal gas compressors for all applications. Unfortunately, all applications are not successful. To insure that all installations are successful, a number of attempts have been made to write the ideal specification to cover all applications. The ideal specification is all that is required, provided, of course, that the specification is ideal. Unfortunately, the resultant specifications like the income tax laws of our country need interpretation.

Careful review of successful and unsuccessful installations generally reveals in the case of the unsuccessful installation a failure to adequately engineer the application and the equipment employed therein. Specifications in a way are a problem to the engineering profession. Specifications are necessary to insure quality or performance as the case may be, but specifications guarantee neither. Three questions regarding specifications are why, who, and how to specify.

Why Specify Centrifugal Gas Compressors?

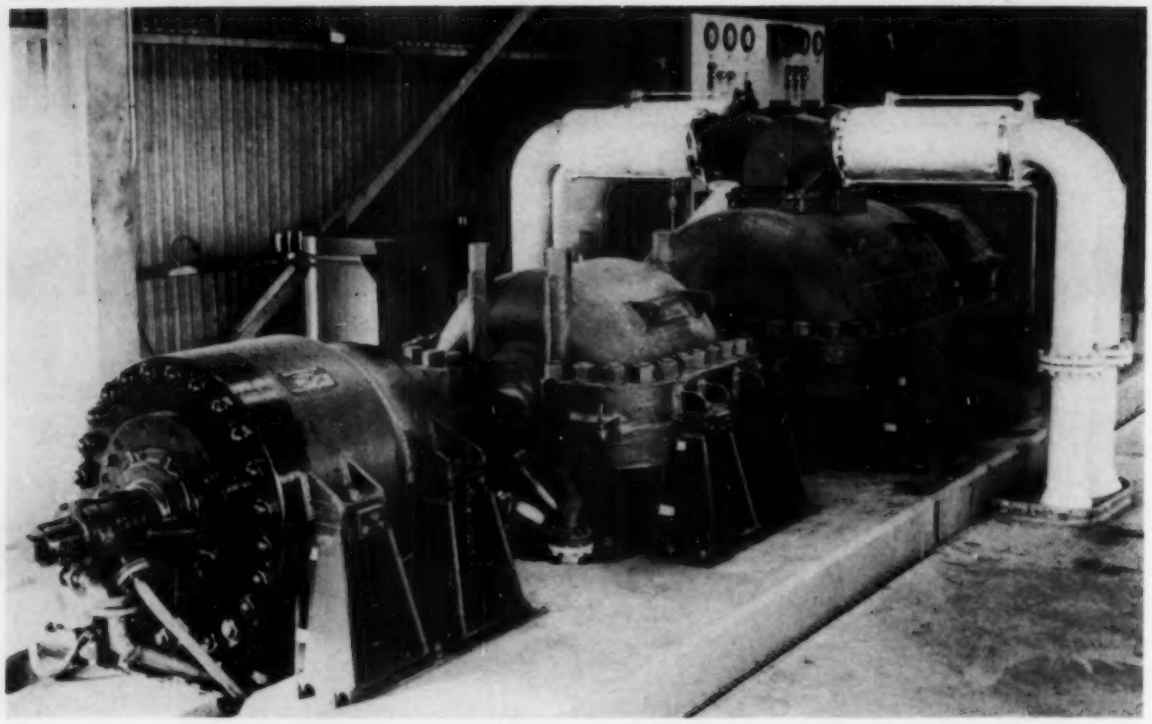
Centrifugal gas compressors must be specified because, with the possible exception of Freon refrigeration compressors, air compressors, and certain single stage blowers, stock or standard sizes are unavailable. This is a natural circumstance since the wide range of properties of gases to be compressed and the conditions of compression effectively preclude the establishment of standard impeller sequences. The manufacturers of centrifugal gas compressors can custom build compressors to handle almost any gas compression job by combining a certain arrangement of impellers and other standard components within a standard case. The point is that manufacturers have available tested components but not compressors. By combining these components in various ways, it is possible to produce an endless series of compressors, each tailored to a specific job of gas compression.

The fundamental principle behind any procurement specification is maximum return on the purchaser's invested capital. A lot has been said about construction of minimum capital cost plants. This approach may not be consistent with the time proved fundamental principle. Properly stated, the rule is "minimum capital cost consistent with maximum return on the investment."

It is important that a centrifugal gas compressor be so specified that the compressor procured will effectively handle the gas compression job and that the plant investment will yield a maximum return.

Who Specifies Centrifugal Gas Compressors?

Despite many beliefs to the contrary, the only specification against which centrifugal gas compressors are built is the manufacturer's specification. The manufacturer must have specifications for all component parts which are used



Centrifugal Gas Compressor Installation...showing "clean cut" installations possible with proper engineering design and installation. Note accessibility for ease of maintenance.

in his compressors. When a purchaser imposes, via rigid definitive specification, requirements differing from manufacturer's standards, costs may increase and some suppliers may be eliminated entirely. Even then, quality or performance may not be improved. An example would be to specify that a shaft must be made from a hammer forging. Without proper heat treatment and machining procedures, a shaft made from a hammer forging will not remain straight in service. If the manufacturer has mastered the heat treatment and machining procedures for bar stock a perfectly satisfactory shaft may be manufactured at less cost. The manufacturer can provide a wide range of components and arrangements thereof. The purchaser, in cooperation with the manufacturer, can work out the best or most suitable arrangement. In the absence of adequate communication, the manufacturer may offer an arrangement less than satisfactory. This can occur in good faith simply because the manufacturer has not been completely informed of the user's problems. The best specification is a joint effort produced by the manufacturer and the purchaser. This specification is still a manufacturer's specification. The purchaser's function is to call to the manufacturer's attention any shortcomings of the manufacturer's specifications and to develop with the manufacturer improved constructions when necessary.

The purchaser will be referred to many times. His duties, responsibilities, and necessary talents are described. Preferably, the purchaser should be the ultimate user of the equipment in question. With time, the user learns a great deal about the equipment operating in the user's plants. This experience is not available to those who do not operate equipment. It is possible for the purchaser to be other than the user provided that no conflict of interests exists in the procurement and that experience is not lacking. Employment of purchasers by users where conflict of interests exists cannot provide the optimum installation. The purchaser must have extensive knowledge covering the many aspects of installation design, installation, maintenance, and operation, as well as required performance to effectively assist the manufacturer.

How Does A Purchaser Specify Centrifugal Gas Compressors?

This is a logical question if the necessity of specifying centrifugal gas compressors by the purchaser is accepted and, at the same time, it is recognized that in the final analysis the compressor will be built to manufacturer's specifications. The purchaser must specify his compressor in a manner that invites the manufacturer to offer the most suitable compressor. Generally speaking, this will be accomplished by specifying performance. Specification of details of construction should be limited initially to essentials and should not be confused with performance. The HOW is a long story.

A centrifugal gas compressor is a custom built item of equipment. Exploiting this fact can result in a clean cut installation capable of high onstream time. Equipment with high onstream time generally requires little maintenance and can be economically attractive. Procure custom built equipment with custom built specifications.

The purchaser is an individual and should be an integrating generalist. An integrating generalist is an improved form of the jack of all trades. To be an integrating generalist, one must have sufficiently wide and varied knowledge and experience to effectively employ the highly developed skills of specialists. Engineers who are successful integrating generalists are interested in engineering. A good example of an integrating generalist is a symphony orchestra conductor. This conductor may not be able to play all musical instruments or even some as well as the specialists, but he

is able to blend the skills of many musicians to produce music.

Procurement of a compressor will follow three basic steps. To activate the process the purchaser requests quotations, reviews the various offerings, and finally, with the successful manufacturer, jointly prepares a construction specification covering equipment capable of meeting operation and maintenance requirements. The degree of success obtained will depend, to a large extent, on the engineering skill, interest, and experience of the purchaser.

STEP ONE. . . is the request for quotation and its specification. This specification is in two parts: Operating conditions which define the gas compression job and informative notes which convey to the compressor manufacturer the rest of the story. Informative notes convey suggestions about constructional details or clarify operating problems. Gas compositions are not exact any more than suction and discharge pressures — or suction temperatures. Tell the whole story of how gas composition and properties vary and relate suction and discharge conditions. Capacity is not fixed as it too will cover a range. It may be of value to indicate an interest in potential increases of capacity. So tell the story about the intended operating point, the uncertainty, and the capacity range. In all probability, the compressor manufacturer can, by judicious selection of components, cover considerable range without too much sacrifice of efficiency. Little value can be placed on high efficiency at some fictitious operating point where the compressor may never operate. Indicate special problems such as — the gas is corrosive due to traces of — or, that temperature sensitivity exists above —°F. Tell which metals resist corrosion but do not close the door by saying that "the rotating assembly is to be constructed of type #— metal." A centrifugal compressor is a mechanical device having certain highly stressed parts of intricate construction. Least cost will occur when materials meeting both chemical and physical properties are selected from those with which the manufacturer has had experience in fabricating.

While it is within the province of the purchaser to primarily specify performance, some mechanical construction specifications are permissible provided they are realistic. Mechanical specifications that are permissible include such specifications that all piping connections are in the bottom half of the compressor, that lubricating oil may not contact the process gas, that minimum gas leakage is permitted, or that vibration must not exceed certain limits. These can be realistic because a requirement that piping connect to the bottom half of the case is an indication of how piping will be brought to the compressor — but also say that a mezzanine installation is planned if such is the case. That lubricating oil should not contact the gas could be for a host of reasons — the lubricating oil could be contaminated and rendered unfit for service as a lubricant or it could cause reaction within the gas stream — tell why as the compressor sealing system will probably involve the process gas and lubricating oil in one way or another. If a special lubricant will be necessary, mention this fact early in the game and tell why it is considered necessary. The manufacturer may be able to reduce the problem. Leakage in the case of an air compressor may be of little importance but in the case of valuable, toxic, or flammable gases, appreciable leakage may be intolerable. Be very careful to establish realistic goals regarding gas leakage. Unrealistic goals may be very costly or even unattainable. There is a great deal of difference between no leakage and a small finite amount of leakage. The economics are the purchaser's concern. Vibration is a good thing to avoid and a vibration tolerance in the operating range is more meaningful than a specification of a critical speed.

How does the purchaser discover in advance just what constructional details to specify? This is accomplished by an overall look at the compressor and its part in the process. The purchaser may develop his know-how by critical analysis of existing centrifugal gas compressor installations. It has been said that hind sight is an exact science. The post mortem review is distasteful to some but is necessary if the next installation is to be an improvement — this is the way of progress. Most manufacturers employ data sheets covering the information necessary to permit proper selection of components. These data sheets may be used by the purchaser as a guide or check list. The procedure in centrifugal gas compressor procurement has been likened to a ride on a merry-go-round. The process application must be reviewed from the standpoint of abnormal operation, including start-up, and shut down, as well as normal operation. It is suggested that the purchaser prepare concurrently with the gas compressor specification tentative operating instructions which include start-up and shut-down procedures as well as normal operation. If impossible combinations of operating conditions exist, then process modification should be worked out. The desirable physical arrangement should be considered from operation, maintenance, and construction viewpoints, in that order of importance.

Wide and varied experience of the purchaser is necessary if he is to be able to visualize the installation in advance. From experience, it is possible to evaluate, at least qualitatively, the effect on construction and maintenance costs of various possible physical arrangements. For example, a piping arrangement that requires a minimum of disassembly during maintenance of a gas compressor is sometimes thought to be more costly to construct than one where pipes are routed every which way. The random piping arrangement is evidence of inadequate planning. Experience in the matter tells that while more engineering dollars are spent to design the piping system favoring maintenance, the simplifications that result so reduce the amount of pipe that total construction costs are reduced. The obvious continuing benefit of the arrangement favoring maintenance is lessened cost and unproductive time during maintenance periods. Experience shows that the carefully designed, easy-to-maintain installation requires little maintenance. Again, within the limits of his many possible arrangements, the compressor manufacturer can help by providing the compressor easiest or most convenient to pipe. The purchaser must get his story about piping arrangements across to the manufacturer. It is desirable to favor operation and maintenance viewpoints at the expense of construction involvements because the compressor will be installed only once but will be operated and maintained for many years. Arranging auxiliaries and piping in a way that does not impair accessibility for maintenance is unpopular with construction groups. To have pipe accessible and easy to remove is a poor buy if another arrangement will eliminate the necessity of removal during maintenance. To work out the best arrangement involves compromise based on clear thinking and experience.

Driver

The sort of driver to be employed must be considered not only from the basis of constant versus variable speed but also from the standpoint of installation. In terms of flexibility, a steam turbine will be the most flexible driver and an electric motor and speed increasing gear box the least flexible driver — an internal combustion engine may be of intermediate flexibility and is a very special case because of its torque-speed characteristics. The control system must be carefully considered as the ideal control system will be common to the process, the gas compressor, and the driver. This arrangement leads to the fewest number of instruments

"Improved communications between manufacturers and users of equipment" ... now the author's primary concern after 25 years' work in petroleum-derived chemicals manufacturing and as Head of the Engineering Development Section of Shell Chemical Corporation's Head Office Engineering Department

and the greatest reliability. Auxiliaries such as lubrication systems and gas coolers must be considered concurrently and cannot be arbitrarily selected. For example, careful consideration of lubrication systems may permit consolidation of the system required for the compressor with that of the driver. Considerable reduction in cost through simplification and improved reliability is possible. Auxiliaries, controls, and the driver should be considered from the standpoint of what they may look like or involve.

The suggestion here is that the purchaser actually undertake the overall engineering of the installation and not attempt to sub-contract the engineering. In considering the many facets of the problem before preparing any specification, it is possible to specify the minimum, adequate equipment required to do the job. The purpose of a specification including constructional details in addition to performance requirements is to invite the manufacturers to offer the most suitable equipment. The most suitable equipment is that which provides the highest return on invested capital over the years.

STEP TWO ... is the evaluation of manufacturers' offerings. Manufacturers' quotations will cover a fairly wide selection of gas compressors, all represented as being able to do the job that the customer has in mind. These quotations will often be backed up with long lists of presumably successful compressors supplied for similar applications. By no stretch of the imagination can these testimonials be considered to be any guarantee of success. Each user has his own standards of performance. One user may consider 98 percent onstream time unacceptable and the next be quite content with a lesser onstream factor. A good rule is to "shoot for the moon" — 100 percent onstream factor. Further, it must always be borne in mind that a successful installation owes its success to **good design** and **installation.** The best equipment will not perform if crippled by poor installation. Intelligent operation and competent maintenance are continuing factors influencing success. That a compressor installation has proved successful for one purchaser is no guarantee that another will fare as well. In evaluating quotations, the user must examine and explore each in great detail to ascertain how each offering fits into the overall scheme. Initial installation, operation, and maintenance must all be explored in turn. Generally speaking, the offering of one manufacturer will appear best. Before awarding the business, some discussion should be held with representatives of the best manufacturer and any others whose equipment appears suitable. This discussion with runners-up is important to avoid missing a better compressor because of a poorly prepared quotation. Poorly prepared quotations may be the result of unrealistic deadlines set by the purchaser. Haste makes waste.

STEP THREE ... is the actual procurement of the gas compressor. When decision has been made, final specifications must be prepared. These specifications are prepared by the equipment manufacturer with the help and guidance of the purchaser. The specification must be complete in all details so that no doubt exists on the part of the purchaser as to what will be received and its suitability and on the part of the manufacturer as to what is to be supplied. This close cooperative effort quite often results in modification and improvement of equipment designs that have been considered standard for a long time. When the gas compressor has been selected, it is time to select the driver, the auxiliaries, and the controls. The gas compressor is selected first because it is the primary item and establishes other requirements such as the speed and power of the driver. These procurements will follow the same pattern employed in selecting the centrifugal gas compressor. Sufficient knowledge of this additional equipment is necessary to avoid finding out too late that the unit cannot be constructed conveniently. The point is that the arrangement of mechanical details of the centrifugal gas compressor must have taken into account the probable design of the driver and the auxiliaries.

Having carefully considered stepwise each component piece of equipment and made its procurement in the light of its inter-action with other pieces of equipment, the actual installation design or drawing of plans may be undertaken. This involves design of foundations, piping, buildings, and instrument or control panels. Even though each class of work will be handled by specialists, it is necessary that the purchaser retain direction and control, as all of the equipment which has been procured was procured to be installed in a certain, special manner. For instance, it is not unusual to find instrument panels located for ease of installation or other unrelated reasons. The instrument panel should be visible to the operator during starting and stopping of a gas compressor unit. Adherence to the concept will produce an installation capable of trouble-free operation and one which is easy to maintain. Only good installation design and installation will permit maximum performance of equipment. Once installed, deficiencies are difficult to correct. Regrettably, it must be stated that in most cases of poor performance of equipment, the greater fault is in the installation and not the equipment itself.

The mechanical complexity and operating limitations of centrifugal gas compressors preclude the use of rigid procurement specifications prepared prior to procurement. Centrifugal gas compressor procurement will be most successful when handled with the manufacturer on a performance basis. It is the purchaser's right to specify performance and his duty to review the manufacturer's offering to evaluate the chances of achieving the required performance. Critical review of existing installations will reveal the merit of the engineering approach as compared to the rigid specification method. Specifications are necessary to insure quality or performance but guarantee neither unless prepared jointly by the manufacturer and the user.

A great deal has been written into specifications about responsibility. The equipment manufacturer is always responsible for his equipment to the same degree as his control in design and construction. **No catch-all responsibility clause can hold a manufacturer responsible for deficiencies in the purchaser's engineering or know-how. Those purchasers substituting rigid definitive specifications with catch-all responsibility clauses for the cooperative approach will not only fail to obtain the best equipment but also will be faced with costs in excess of the minimum consistent with the maximum return on the investment.** The centrifugal gas compressor manufacturer builds only a portion of a gas compression system and, therefore, cannot be responsible for the whole — only the purchaser has overall responsibility. The user is the most interested purchaser.

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STEAM TRAPS

. . . A guide to selection and installation

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WHILE STEAM TRAPS are a minor cost in plant construction, improper trap selection or installation could cause serious operating and maintenance problems. **There is no steam trap that is ideal for all services.** The best trap for one application may be a poor choice for another service. On the other hand, it may not be practical to use the ideal trap for each service because of the large inventory of spare traps and parts. This article presents the advantages and disadvantages of each basic type trap to aid in determining the best steam trap for a given application or the one trap which will satisfy the largest number of services at hand.

I. DESCRIPTIONS

The following seven basic steam trap types are described considering basic operation, selection difficulty, price class and special desirable or undesirable features. No consideration is given to maintenance cost because this may vary considerably. In general, however, the traps with few parts and rugged construction will survive best.

Inverted bucket trap . . . The inverted bucket steam trap is a mechanical unit containing a bucket inverted so that it will float when filled with steam but will lose buoyancy when condensate displaces the steam. Since it discharges at steam temperature it requires no precooling of the condensate. It will not pass steam unless it loses its prime. It is one of the lower priced traps especially in cast iron. Inverted bucket traps require priming, discharge condensate intermittently, are not freeze proof and have to be selected for proper orifice size. The orifice must be large enough for design load and small enough to allow bucket weight to overcome pressure differential across the orifice thus opening the valve.

Open bucket type . . . The open bucket trap operates mechanically with an upright bucket that will float in condensate. The condensate finally overflows causing the bucket to lose buoyancy and drop, opening the discharge valve. It requires priming but does not lose its prime as easily as the inverted bucket trap. It discharges condensate at steam temperature and will not pass steam unless it loses its prime. It is not freeze proof, discharges condensate intermittently and is relatively high price. Like the inverted bucket trap the orifice has to be specially specified for operating conditions.

Float traps . . . The float trap is a mechanical trap containing a ball float. Condensate in the trap raises the float opening the discharge valve. Condensate is discharged continuously, maintaining relatively accurate temperature control. It does not need priming and will not pass steam. It is not freeze proof and will not pass air unless it has a built-in thermostat. Proper selection of the orifice is required and is, in general, a high price trap. Some types can be inverted and used as an air vent in liquid service. The trap and orifice size must be selected for a particular service.

Bellows thermostatic trap . . . This trap contains a bellows partially filled with liquid that remains compressed as long as cold condensate is available aided by the pressure outside of the bellows. When the surrounding condensate temperature becomes high enough to vaporize the liquid, the corresponding internal pressure overcomes the outside pressure, expanding the bellows and closing the valve. This temperature increases as the surrounding pressure increases. Therefore no adjustment is needed for varying steam pressure. It has a large capacity for its size and price, but discharges condensate below steam temperature and normally intermittently. This trap is good where dry steam is not absolutely essential. It is a good air eliminator and most types are freeze proof. It is medium priced, does not require priming, will not pass steam and there is no orifice sizing problem. The trap and 18 in. of inlet pipe must not be insulated to provide some precooling of condensate if dry steam is essential.

Leaf thermostatic trap . . . The leaf thermostatic trap has one or more bimetallic strips which close the discharge valve slightly before steam temperature is reached. As the upstream pressure tends to open the valve, the corresponding temperature increase forces the bimetallic strips to close the valve. Superheated steam will cause additional closing force. An increase in downstream pressure will also add closing force but with no change in upstream steam temperature the condensate must be subcooled to open the valve. Therefore, some adjustment of the bimetallic element should be made for varying condensate pressure. This trap has a large capacity, need not be primed, does not leak steam and discharges condensate continuously. The valve

acts as a check valve and most types have a built-in strainer. It is a good air eliminator, can be installed freeze proof, and only minor orifice selection problems are involved. It is a medium priced trap and can be purchased with integral blocks and bypasses or with external condensate temperature control. No insulation around the trap and 18 in. of inlet pipe is essential to subcool condensate if dry steam is to be maintained.

Variable orifice trap . . . The variable orifice trap works on the difference of flow capacity of steam and condensate through an orifice. On low condensate loads it will pass steam. It has a large capacity, and discharges at steam temperature. It is a good air eliminator. The variable orifice trap is good where the condensate load is nearly constant. It is not freeze proof, does not need priming and selection is based almost entirely on connection size.

Thermodynamic traps . . . The *impulse thermodynamic trap* is a small steel trap working on the double orifice principle. When cold condensate flows through two orifices in series a relatively small pressure drop occurs allowing the valve to remain open. As condensate gets hotter it flashes causing greater pressure on top of valve due to greater pressure drop in the outlet orifice. The valve closes and will remain closed as long as a small amount of steam is bled through the second orifice. If condensate enters the trap the pressure drop decreases and allows the valve to open again. This trap discharges condensate slightly below steam temperature. The back pressure cannot exceed 25 percent of the inlet pressure and it is not freeze proof. The trap bleeds steam at about 1 to 2 percent of its capacity when no condensate is present. They are made only in steel, but are low priced for steel and compare with medium priced cast iron traps. Selection is by connection size.

Disc type thermodynamic trap is similar in size and operation to the impulse. As long as cold condensate passes under the disc, the trap remains open. As relatively high velocity steam passes under the disc a low-pressure area is created. With nearly steam pressure on top of the disc the trap closes. When the steam on top of the disc condenses, it lowers the pressure allowing the disc to lift. If no condensate is present, the trap will close again. There is an intermittent bleeding or wasting of steam and similar to the impulse trap, is in the order of 1 to 2 percent of the trap capacity. This trap can be installed freeze proof and can operate with a back pressure no greater than 50 percent of inlet pressure. It is made of stainless steel only. Its price is similar to the impulse trap and is selected by connection size.

II. PREFERRED SELECTION

Header drains and steam separator drains . . . Traps for header drains and steam separator drains should discharge condensate at steam temperature to maintain dry steam in lines at all times. The inverted bucket, open bucket and float trap are recommended for saturated steam lines. The inverted bucket is preferred because of price, and it is a fair air eliminator. For superheated steam lines thermostatic traps are preferred.

Reboilers . . . Reboiler traps should drain condensate continuously at steam temperature. Float traps and variable orifice traps are recommended. Float traps with built-in thermostat are preferred as variable orifice traps pass steam on low flow. Leaf Thermostatic traps can be used where freeze proof protection is required but flooding the reboiler may be a problem. A cooling leg can be provided upstream of trap to eliminate this problem.

TABLE 1.

Type Trap	Inverted Bucket	Open Bucket	Float Trap	Bellows Thermostatic	Leaf Thermostatic	Disc Type Thermo-dynamic	Impulse Thermo-dynamic	Variable Orifice
Discharge Principle	Gravity	Gravity	Gravity	Temperature	Temperature	Specific Vol.	Specific Vol.	Specific Vol.
Discharges condensate at steam temperature	Yes	Yes	Yes	No	No	Nearly	Nearly	Yes
Air Elimination	Fair	Poor	Poor	Good	Good	Fair	Fair	Good
Can be installed freeze proof	No	No	No	Yes	Yes	Yes	No	No
Strainer recommended	Yes	Yes	Yes	No	No (Usually built-in)	Yes	Yes	No
Requires Priming	Yes	Yes	No	No	No	No	No	No
Can Bleed Steam	No	No	No	No	No	Yes	Yes	Yes
Continuous Condensate Discharge	No	No	Yes	No	Yes	No	No	Yes
Can be installed in any position	No	No	No	Yes	Yes	Yes	No	No
Can stand water hammer	Yes	Yes	No	No	Yes	Yes	Yes	Yes
Effect of variable pressure	Valve won't open on high pressure	Valve won't open on high pressure	Valve won't open on high pressure	Changes capacity only	Changes capacity only	Back press can not exceed 50% of inlet press.	Back press can not exceed 25% of inlet press.	Changes capacity only
Effect of variable condensate load	None	None	None	None	None	Very slight	Very slight	Leaks stm. at low flow
Capacity Limit	Medium	Medium	Large	Large	Large	Medium	Medium	Large
Price Class (Steel)	Medium	High	High	Medium	Medium	Low	Low	High
Price Class (Iron)	Low	High	High	Medium	Medium	Medium-made in steel only	Medium-made in steel only	High
RECOMMENDED SERVICES: (Cost not considered)								
Header Drains (Superheated Steam)	*	*	Fair	Good(500 deg. max.)	Good	Fair	Fair	*
Header Drains (Saturated Steam)	Best	Good	*	Fair	Fair	Good	Good	*
Steam Separator Drains	Best	Good	*	Fair	Fair	Good	Good	*
Reboilers	*	*	**Best	*	Good	*	*	Fair
Unit Heaters	Good	*	**Best	Good	Good	Good	Good	*
Steam Tracing	Fair	*	*	Good	Good	Good	Good	*

**With Thermostatic Air Vent
*Normally not recommended in this service

Unifining Process

Licensed by: Union Oil Company of California
Universal Oil Products Company

DESCRIPTION: This catalytic hydrogenation process is used to remove sulfur, nitrogen, oxygen and other contaminants from either straight-run or cracked petroleum fractions. The process achieves the pretreatment of catalytic reforming feedstocks; improves odor, color, gum, storage stability, and burning characteristics; improves cetane number of diesel fuels, lead susceptibility of gasoline and the catalytic cracking characteristics of cycle oils and gas oils. Commercial installations apply Unifining to straight-run, thermal, catalytic and coker naphthas; straight-run kerosene, diesels, and burner oils; vacuum, visbreaker, and coker gas oils; catalytic cycle stocks and aromatic distillates.

The process is flexible and may be designed to meet the requirements of any desired treatment. The accompanying diagram shows an equipment arrangement for preparing a high quality naphtha, a diesel blending stock and catalytic cracking feedstock from a feed mixture of vacuum straight-run and coker gas oils.

The feed is combined with hydrogen recycle gas, preheated by heat exchange with reactor products and heated to the required inlet temperature. The reactor products, after heat exchange, are cooled and flow to a high-pressure separator. The hydrogen-rich gas is recycled to the reactor. In some applications gas from the high-pressure separator is passed through an absorber for removal of hydrocarbons. The high-pressure separator liquid flows to a low-pressure separator where additional gases are removed. Liquid from the low-pressure separator may be sent to a stripper, stabilizer or other comparable equipment. In this diagram liquid from the low-pressure separator is fractionated into a naphtha stream, diesel blending stock and catalytic cracking charge.

UNIFINING GAS OILS

	Charge[a]	Naphtha	Diesel	Catalytic Cracking Feed
Gravity, °API	31.4	61.6	34.8	26.4
ASTM Dist, °F				
Initial	153	95	402	571
50 Percent	665	260	515	728
95 Percent	840	378	624	877
Sulfur, wt. percent	1.91	0.12[b]	0.19	0.53
Conradson Carbon	0.375		0.024	0.247
Metals, ppm				
Nickel	0.30			0.07
Vanadium	1.90			0.35

a. Vacuum distillation
b. Mostly dissolved H_2S

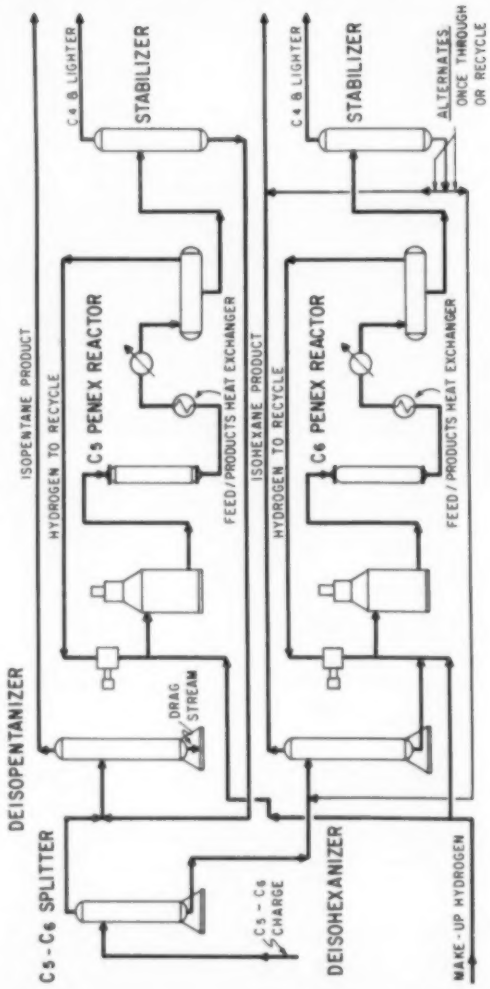
UNIFINING COSTS

	Reformer Feed	Stove Oil and Diesel	Wide-Range Distillate	No. 2 Heating Oil
Throughput, bpd	16,000	900	5,000	12,000
Direct operating costs, ¢/bbl				
Labor & supplies, Maintenance, Utilities	6.3	3.7	5.7	7.7
Catalyst	0.7[a]	0.6[a]	0.5[a]	1.2

a. Original catalyst still in service. Cost based on life as of May, 1959.

Penex Catalytic Isomerization

Licensed by: Universal Oil Products Company



REACTOR OPERATING CONDITIONS:
500-900°F; 300-1000 psi
CATALYST: Platinum-containing (UOP 1-3)

Penex Catalytic Isomerization

Licensed by: Universal Oil Products Company

DESCRIPTION: This process is for isomerization of C_5 through C_7 hydrocarbons over a platinum-containing catalyst in the presence of hydrogen. Maximum yields are obtained by separately processing close-cut fractions; in small-capacity installations, however, it might be more desirable to process mixtures because of smaller investment required.

The flow scheme assumes mixed C_5-C_6 charge and individual isomerization of the two fractions. Note that the fractionation is such that cyclics and other heavy ends are removed by dragstreams.

Processing may be once-through. However, because of equilibrium consideration, recycling is desirable in C_5 Penex with deisopentanizing of both feed and recycle streams.

In C_6 Penex, operating conditions employed will not appreciably alter C_6 cyclics. Their presence in the C_6 fraction should be minimized by careful fractionation ahead of the splitter column. Equilibrium considerations likewise dictate the removal of at least part of the isomerized product from the recycle to achieve greatest upgrading of the total C_6 stream.

Catalyst regeneration is not employed. Carbon steel construction is permitted because both catalyst and reaction products are non-corrosive.

PROCESS VARIABLES:

Conversions approaching equilibrium for C_5 and C_6 isomerization are achieved in single-pass and recycling enables virtually complete conversion.

Highest yields of iso-compounds are obtained when pentanes and hexanes are isomerized separately, and when recycling of the unconverted hydrocarbons is practiced. Hydrogen make-up requirements are minor. Hydrogen consumption in C_5 isomerization is about 40 SCF/B (10 SCF/B to chemical loss and the remainder in solution in the product from the separator); in C_6 isomerization, about 50 SCF/B (25 SCF/B each in chemical and solution loss).

FEEDSTOCKS AND PRODUCTS:

Component, Vol. %	C_5 - C_6 Feed	C_5 - C_6 Splitter: Overhead To C_5 Penex	C_5 - C_6 Splitter: Bottom To C_6 Penex	Penex Products*: C_5 Product	Penex Products*: C_6 Product
i-Butane	0.1	0.3	–	0.9	–
n-Butane	0.2	0.5	–	–	–
i-Pentane	20.2	50.4	0.1	94.2	0.1
n-Pentane	18.9	45.8	0.9	4.9	0.8
Cyclopentane	0.7	1.1**	0.5	–	0.4
Dimethylbutanes	5.5	1.8**	7.9	–	18.2
Methylpentanes	25.3	0.1**	42.2	–	58.5
n-Hexane	24.0	–	40.1	–	12.6
Methylcyclopentane	2.8	–	4.6	–	7.2
Cyclohexane	1.0	–	1.6	–	0.4
Heptane and heavier	1.3	–	2.1	–	1.8
	100.0	100.0	100.0	100.0	100.0
Yields, Vol. % reactor charge				99.0	98.2
Research Octane Ratings					
Clear	65.4	–	–	91.0	74.8
Plus 3 ml. TEL/gal.	88.6	–	–	103.0	93.0

*Recycle operation.
**Assumed withdrawn as a dragstream from fractionator.

SERVICE FACTOR: 90+ percent.
OPERATING PERSONNEL: 1½ men for C_5 or C_6 isomerization alone; 2 men/shift for C_5/C_6 combined.
OPERATING COSTS:

C_5 Penex — 2,580 B/SD Fresh Feed, Total Recycle Operation

Unit Cost, erected*	$ 990,000
C_5 feed 2580 B/SD	($384/bbl.)
iC_5 product 2552 B/SD	

Operating Cost**	Cents per barrel
Labor and supervision	7.4
Utilities	17.5
Maintenance, taxes and insurance	6.2
Catalyst replacement	2.0
	33.1

C_6 Penex — 3,800 B/SD Fresh Feed, Partial Recycle Operation

Unit Cost, erected*	$1,190,000
C_6 feed 3800 B/SD	($313/bbl.)
iC_6 product 3732 B/SD	

Operating Cost**	Cents per barrel
Labor and supervision	3.3
Utilities	11.3
Maintenance, taxes and insurance	4.8
Catalyst replacement	3.9
	23.3

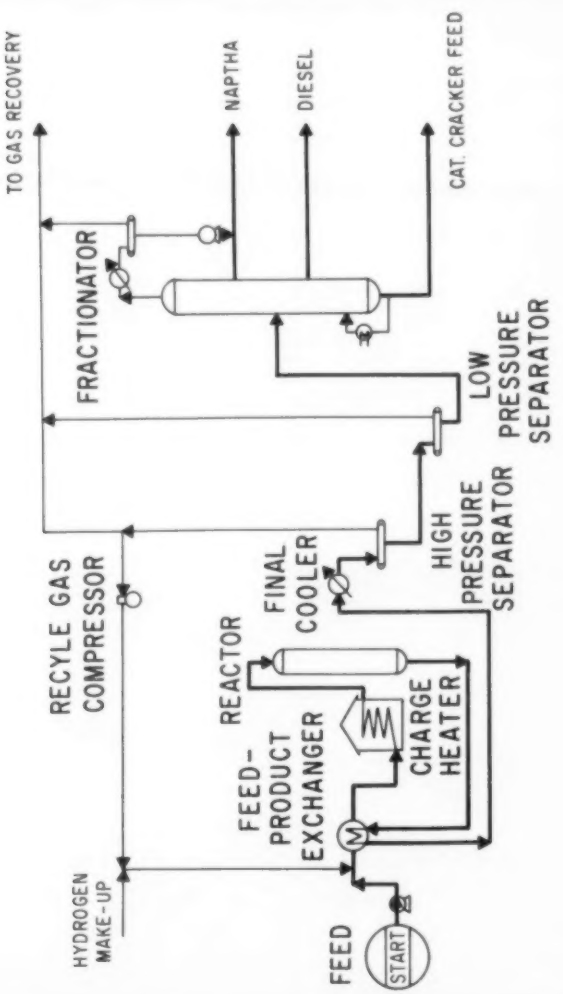
C_5-C_6 Splitter — 6,464 B/SD $310,000

C_5 feed	2580 B/SD
C_6 feed	3800 B/SD
Dragstream	84 B/SD

*Catalyst inventory excluded.
**Royalty excluded.

Unifining Process

Licensed by: Union Oil Company of California
Universal Oil Products Company



Steam tracing . . . Steam tracing traps can discharge condensate below steam temperatures. They should be good air eliminators, small in size and freeze proof if condensate is not returned. Thermostatic or thermodynamic traps are recommended. Thermodynamic traps are preferred where steel traps are required, because of price. Leaf thermostatic traps are preferred where strainers or check valves are required. Bellows thermostatic traps are satisfactory and price is competitive in cast iron.

Unit heaters . . . Traps for unit heaters should discharge at or near steam temperature and eliminate large quantities of air. Float traps with built-in thermostats are preferred but may be expensive. The thermodynamic trap is small, light weight, and inexpensive when steel is required. Inverted bucket trap is satisfactory and inexpensive. The leaf thermostatic trap discharges continuously, is inexpensive if strainers and check valve are necessary. The bellows thermostatic trap is satisfactory and is moderately priced.

Table 1 will give an overall look at the several basic type steam traps and the features distinguishing one from another. **However, each manufacturer is constantly developing new features to solve particular disadvantages he may have.**

III. STEAM TRAP PIPING ARRANGEMENT

Closed type discharge . . . Condensate should discharge to a return header or collecting system when the general policy for the plant is to recover condensate and when the trap discharge would be hazardous or objectionable such as indoors.

Atmospheric type . . . Condensate should be discharged to sewer or waste when the general policy for the plant is to waste condensate; when the steam pressure is not great enough to overcome condensate pressure plus line and trap pressure drop; when it is not practical to return the condensate, as from a remote location; when the flash steam is not objectionable and as a freeze protection method.

Freeze-protected traps . . . When traps are subject to continuous use in sub-freezing atmosphere they should be mounted above the condensate header on closed type discharge with the trap outlet draining to the condensate header. On atmospheric type discharges the trap should be mounted and piped so the discharge will drain to atmosphere without any pockets. Thermostatic traps with bottom discharge or thermodynamic traps mounted in vertical should be used for freeze-proof systems.

PIPING TIPS

1. Trap inlet lines should be free draining and as short as possible. Thermostatic traps should have 18 in. minimum of bare line from the header or equipment to the trap inlet for condensate cooling.
2. Condensate return lines should be as short as possible with a minimum of pocketing.
3. Normally traps operating on different steam pressures should return to the condensate header separately. A check valve can be installed in the condensate return lines where there is a possibility of condensate back pressure exceeding the trap inlet pressure. Some traps can be bought with a built-in check valve.
4. Size of trap group return lines for ½ in. or ¾ in. traps are recommended as:

1 or 2 traps	¾ in. return line
3 or 4 traps	1 in. return line
5 to 10 traps	1½ in. return line
over 10 traps	2 in. return line

5. Strainers should normally be installed ahead of traps.
6. A trap bypass is not normally recommended except on critical services or inside buildings.
7. Cast iron (semi-steel) traps are recommended for saturated steam pressures 200 psig or below while ductile iron may be considered for higher steam pressures before using steel.
8. In addition to the valves at the condensate and steam headers:

   (a) Normally four valves should be furnished with each steam trap on closed discharge systems:

   1 — line block upstream of trap

   1 — line block downstream of trap

   1 — blowdown valve either in strainer or line upstream of trap

   1 — drain or test connection downstream of trap.

   (b) Normally two valves should be furnished with each steam trap on open discharge systems:

   1 — line block upstream of trap

   1 — blowdown valve either in strainer or line upstream of trap

IV. STEAM TRAP PIPING DETAILS

The following are four basic services with condensate discharge either to a return header or sewer. The general schematic and sequence of piping materials for each detail will apply whether the trap inlet and outlet connections are on the side, top or bottom. Freeze proof traps should have

---

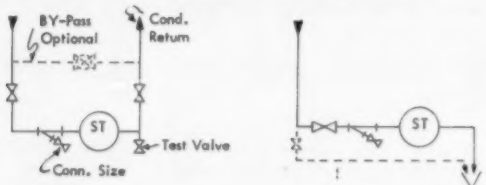
Wallace W. Westervelt *is now process equipment engineer for the Treco Construction Division of Vitro Engineering Company, formerly The Refinery Engineering Company. In his three years at Treco, he has also served as piping designer and engineer in the utilities design section. Previously, Westervelt was general refinery engineer and assistant maintenance foreman during seven years at Col-Tex Refining Company. He received his BS degree in chemical engineering at the University of Oklahoma in 1949 and is currently doing graduate work at the University of Tulsa school of petroleum engineering.*

R. L. Hippensteel *is utilities engineer for the Treco Construction Division of Vitro Engineering Company, formerly The Refinery Engineering Company. He has been with the firm six years, previously serving in the piping-design department. Before joining Treco, Hippensteel spent two years in the plant engineering department of Douglas Aircraft Company in Tulsa, where he was project engineer for new facilities. He was graduated from Michigan State University in 1951 with a BS degree in mechanical engineering.*

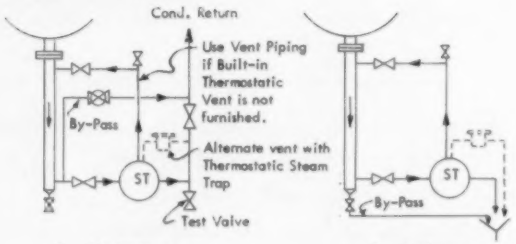
HOW TO SPECIFY...

a bottom discharge with top or side inlet. Where strainers are shown, it is preferred they be built into the steam trap. Under Item E three methods for handling condensate from a vacuum system are illustrated.

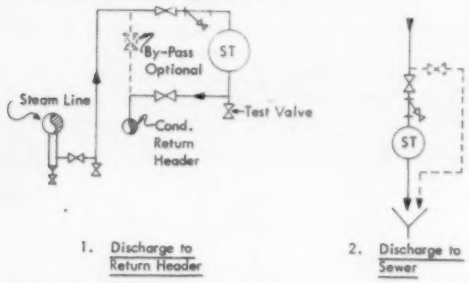
A. STEAM HEADER OR SEPARATOR DRAINS



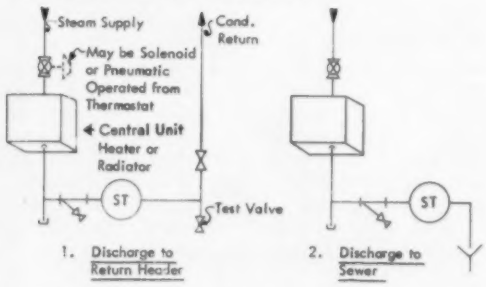
B. REBOILER TRAPS



C. FREEZE PROOF TRAPS

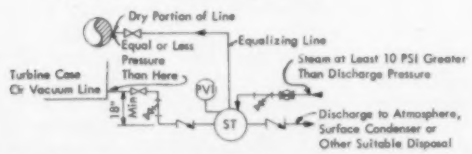


D. BUILDING HEATING TRAPS

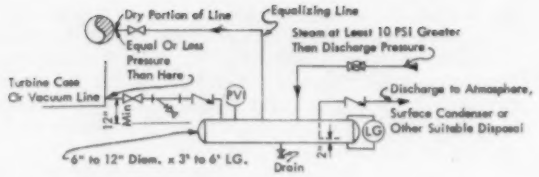


E. VACUUM SERVICE

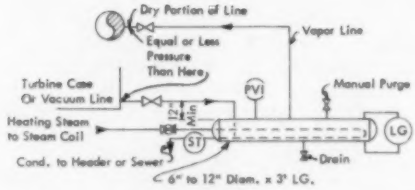
(Primarily for condensing Turbine Case Drains)


Dry Portion of Line
Equal or Less Pressure Than Here
Equalizing Line
Steam at Least 10 PSI Greater Than Discharge Pressure
Turbine Case Or Vacuum Line
PVI
18" Min.
ST
Discharge to Atmosphere, Surface Condenser or Other Suitable Disposal

1. Vacuum or Lifting Traps


Dry Portion of Line
Equalizing Line
Equal Or Less Pressure Than Here
Steam at Least 10 PSI Greater Than Discharge Pressure
Turbine Case Or Vacuum Line
PVI
12" Min.
Discharge to Atmosphere, Surface Condenser or Other Suitable Disposal
LG
6" to 12" Diam. x 3" to 6" LG.
Drain

2. Manual Blowcase



3. Automatic Blowcase

V. TRAP LOCATIONS IN PIPING

Steam traps should be located in all low points or pockets, ahead of risers or major takeoffs and in long runs of piping to minimize warm-up time. The illustration and Table 2 can be used as a guide to locate steam traps in piping systems.

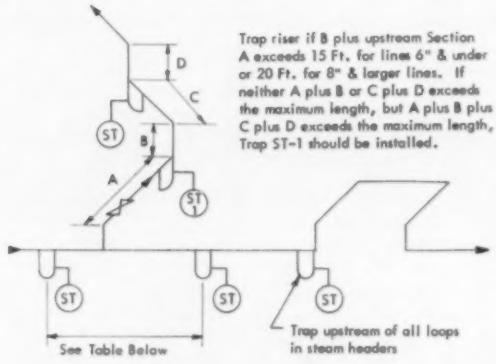

Trap riser if B plus upstream Section A exceeds 15 Ft. for lines 6" & under or 20 Ft. for 8" & larger lines. If neither A plus B or C plus D exceeds the maximum length, but A plus B plus C plus D exceeds the maximum length, Trap ST-1 should be installed.
D
C
B
A
ST
ST-1
See Table Below
Trap upstream of all loops in steam headers

Table 2 is based on the use of minimum size traps (500 lb per hr minimum condensate at steam temperature) and steam required for initial warm-up of insulated piping from 80 F in 20 to 30 minutes. Practical applications seldom allow trap spacing over 300 ft although the steam trap will handle condensate collected in 500 ft or more of small sized piping. For the larger lines the distance between traps may be increased by using larger capacity steam traps.

TABLE 2.

Pipe Size, in.	L Values—Max. Horizontal Run Between Traps Steam Pressure psig						
	10	20	50	100	200	300	400
Under 6	500	500	500	500	500	500	500
6	500	500	480	410	340	310	280
8	490	410	320	270	230	205	190
10	350	280	230	190	160	150	140
12	280	235	180	155	130	120	110
14	220	185	150	125	105	100	100
16	170	140	110	100	100	100	100
18	135	110	100	100	100	100	100
Over 18	100	100	100	100	100	100	100

★ ★ ★

Aids to Air Fin Cooler Specification

Here is a helpful discussion for design engineers who find it necessary to acquaint themselves with air fin cooler design

H. Neil Worsham
Chief Engineer
Coynco Products, Inc.
Tulsa, Oklahoma

The widespread acceptance of air fin coolers as a useful process tool has presented to the engineer the usual problem of a new equipment specification. It is therefore desirable for the possible user of such equipment to become familiar with its design and application. This presentation includes the information necessary to satisfy the basic requirements for air fin cooler specification.

DESCRIPTION OF EQUIPMENT

General arrangement of air fin coolers is such that ambient air is forced or induced by a fan to flow across a bank of externally finned tubes. This air becomes heated and is usually discharged vertically into the atmosphere at a considerable elevation above grade.

The average air cooler is made up of a horizontal section containing finned tubes, steel supporting structure with plenum chamber and fan ring, axial flow fan, drive assembly, and miscellaneous accessories such as louvers, fan guards, fencing, and hail screens.

Finned tube sections usually consist of from four to eight vertical rows of spirally finned tubes. The headers for these sections may be of the rectangular box type with plugs opposite the tube ends, or of the removable cover type. It has been found that the plug type headers are satisfactory for almost all types of services. When gasket type plugs are used the headers may be designed to hold even high pressure hydrogen services. Removable cover type headers are usually used where complete access to the interior of the headers is required for cleaning purposes, or where the user feels that a continuous gasket seal around the header is more satisfactory for his particular service than the many individual gaskets used with plugs.

Typical fan drives are steam turbines or electric motors through gears or V-belts, gas engines through gears, or hydraulic motors direct connected, or through gears. Some fans are driven from such prime movers as compressors with a V-belt take-off from the flywheel to a jack shaft and through a gear or V-belt to the fan. Obviously, the drive assembly may be varied to suit unique requirements.

Supporting structure should be designed not only to carry the weight of the unit, the wind load, and desired seismic load, but also to be so constructed that vibration resulting from the driver and fan is properly absorbed.

OPERATIONAL CONSIDERATIONS

Air fin coolers inherently require a large plot area, as compared with the area required for the installation of similar duties in shell and tube equipment. Also, it is desirable that the hot air discharge of the cooler is not too low, where it may interfere with the function of other equipment or result in some discomfort to personnel. These two problems are frequently solved simultaneously by installing the equipment on pipe racks or on the top of buildings. It should be kept in mind, however, that the structure must be elevated to such a height that there is a minimum of interference to the flow of ambient air from the atmosphere to the underneath side of the unit and the entrance to the fan. Also, the units should be well removed from other equipment which generates heat in a form that would interfere with the proper operation of the air cooler.

Since the design engineer is very likely more familiar with the water cooler than with the air fin cooler, perhaps a few points of comparison between the two types of equipment are in order. Water coolers are subject to silt deposition when low water velocities are used, and to various degrees of fouling depending upon tube wall temperatures. In many plant locations the water supply is either inadequate for the total plant requirements, or is of such poor quality that its use results in severe fouling problems. Such undesirable conditions may be further accentuated by corrosion. Here we have a series of adverse causes and effects which might be avoided, or at least minimized, if air coolers were considered.

1. **Elimination of expensive corrosion resistant material** used to protect against foul or salt cooling water. It is not usually necessary to protect air coolers against any corrosive medium except the process fluid. Atmospheric air seldom presents such a problem. When it does, protection for only the steel components is all that is required, and may be accomplished economically and effectively by galvanizing.
2. **Maintenance resulting from fouling,** such as that found in water coolers, is virtually eliminated in air cooling. Observation of installations indicates that the only external fouling experiences were those on installations adjacent to cooling towers, where spray water coated the external surface of the fintubes, and near certain crude oil processing units where the fintubes became coated with oil and subsequently restricted the flow of air by a build-up of dust.
3. **Process temperature control** may be accomplished with no attendant fouling because of low water velocity. Air cooling is peculiarly adapted to cope with this problem. Air is nonfouling. Temperature control may be obtained by varying the air flow with the use of louvers, multiple-speed electric motors, hydraulic motors, adjustable-pitch fan

blades, or any combination thereof. Also the user has the choice of either manually or automatically controlling these devices. Since automatically adjustable-pitch fan blades are somewhat unusual, perhaps a further description of their construction and operation is in order. The majority of the fans used in both water cooling towers and for air cooling have manual blade-pitch-angle adjustment. This is satisfactory if process temperature control is not critical, if maximum cooling is required at all times, or if the power cost for fan operation is extremely low. Usually, however, power costs cannot be ignored, and many processes require close control of temperatures. To reduce the cooling capacity of an air cooler it is necessary only to reduce the air flow. Louvers effect this, but at no power saving.

Horsepower and air quantity may be controlled properly only by controlling the fan speed, and, or the fan-blade pitch. Multiple-speed motors allow a limited number of steps in this direction. Manual fan-pitch adjustment requires a brief shutdown period for each fan, which, under some circumstances is not permissible. It remains, therefore, for the automatically adjustable pitch fan to pick up where the other methods of control stop, by allowing the fan-blade pitch to be changed while the fan is in operation. Since air delivery and horsepower are a direct function of the blade pitch angle, the air flow may be reduced when desired, with a simultaneous saving in power, by reducing the blade pitch. A properly designed unit of this type should have a blade-angle adjustment covering the range of air delivery from full design air flow to reverse pitch at the fan tip. Also, it should accomplish this traverse with a minimum hysteresis. Much of the desired control may be lost if, at a given controlling air pressure, the fan will not reproduce the blade setting when decreasing the blade angle that it had when increasing the angle.

4. Pressure design. It is generally more economical to design for internal rather than external pressure. With air fin coolers, the pressure is internal, allowing full advantage to be taken in both tube wall and header thicknesses.

5. Mechanical cleaning. Last, but of considerable importance, is the fact that with fouling streams inside the tubes, thorough mechanical cleaning is possbile. Convenient access to the inside of the tubes may be through plugs opposite the tube ends or removable covers on the headers.

DESIGN CONSIDERATIONS

Aside from the tubeside film coefficient, which may be easily obtained from well known and reliable published data, the most elusive remaining factors required to complete the design of an air cooler are the air-side film coefficient and the resistance to the flow of air across the outside of the tube. The air or fin-side film coefficient is usually referred to the outside prime tube surface, and for the air velocities normally used, may have values ranging from 125 to 160 Btu per hr-sq ft-F. The resistance to the flow of air is called the static resistance, static pressure drop, or simply the pressure drop, and is measured in inches of water.

A mean temperature difference (MTD) correction is essential for accurate air cooler design. Fig. 1 gives correction factors to be applied for both single pass and multiple pass tubeside flow. In air coolers multiple tubeside passes are possible by using either a side-by-side or over-and-under arrangement. The same temperature approach may be obtained with either the single-tube pass or the side-by-side pass, allowing the same MTD correction to be applied in either case. Obviously, the side-by-side pass is the same as a single-pass coil when it is observed that the ambient air approaches each pass over its entire length. However, the situation is quite different for over-and-under passes, where the approach is more nearly countercurrent. Tests indicate that excellent correlation of results are obtained with the foregoing MTD corrections, even with close temperature approaches. When over-and-under passes are used, a negligible error is introduced when the same MTD correction is applied to either two or more than two passes.

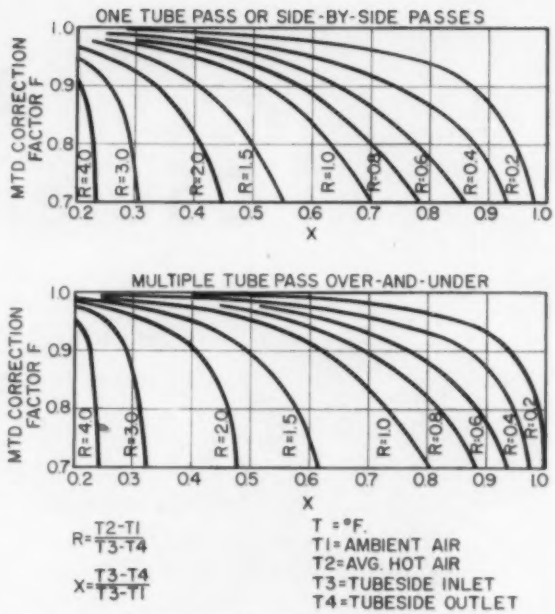


FIG. 1 CORRECTION FACTORS FOR LMTD AIR CROSSFLOW

"Control" numbers. It is often convenient to have "control" numbers at hand when selecting heat exchangers. Among these are MTD corrections for various types of equipment for even out-to-out temperature approaches, that is, when the outlet temperature of both fluids are the same. For shell and tube exchangers with a single pass shell and two tube passes, the MTD correction is approximately 0.8. By knowing this, it is possible to decide immediately by observing only the temperatures whether or not multiple shell passes are required. For the frequent user this is a definite aid. For air cooled equipment the MTD correction for this condition or even out-to-out temperature is approximately 0.91 for single pass and 0.96 for multiple and over-and-under passes.

Air distribution across the coil is seldom uniform, and must be accounted for in the areas of critical performance. Most services do not have close temperature approaches and the distribution factor may be ignored. This is generally the case for outlet process fluid temperatures on the order of 150 to 200 F with 100 deg F air, and where the outlet air does not approach the hot process inlet temperature closer than about 50 deg F. Also there is no problem in a cooler with inlet temperatures of 200 to 300 F and cooling to 120 to 130 F with 100 deg F air. The distribution does become a problem, for example when trying to condense propane at 110 F with 90 deg F air. Here the temperature driving force is extremely low on both the cold and hot ends and a small variation in air distribution will cause an enormous depression of the MTD. The treatment of such situations will be successful only through careful analysis and application of experience.

Performance of the finned tube is strongly influenced by the environment of the tubes. Forced draft arrangements give a somewhat higher air film coefficient than the equivalent induced draft unit. The film coefficient is 0.6 power function of the air velocity, or volume, while the pressure drop is a 1.8 power function. This indicates the sensitivity

of the air flow to the pressure drop. A small error in the design pressure drop results in a large decrease in air volume, which in turn produces a higher air temperature rise and reduces the MTD. The film coefficient is much less affected by a change in air volume than is the pressure drop. Therefore, this shows the difficulty improving the overall performance of a field installation by increasing the air volume.

Fig. 2 illustrates the effect of ambient air temperatures on the capacity of an air cooler. Typical services have been selected, each having considerably different fluid and heat transfer characteristics. Assume the design point to be 100 F air. If the design temperature should have been 95 F, the equipment would be oversized 4 percent for the steam condenser, 8 percent for the jacket water, and 11 percent for the lube oil. If the design temperature should have been 105 F, the undercapacity would be on the same magnitude. This indicates the sensitivity, or lack of it, to the purchaser, giving him for the first time a feel for design. The greatest value of using Fig. 2 is to allow the purchaser to more accurately select the best design ambient air temperature by being able to anticipate the effect on critical services of a varying ambient.

Fig. 3 is intended to illustrate the effect upon the design duty of an insufficient supply of air. The jacket water cooler and steam condenser shown in Fig. 3 indicate a larger decrease in duty than does the oil cooler, when design air flow is not achieved. Fig. 3 shows necessity for full air delivery.

The use of Fig. 2 and Fig. 3 simultaneously is desirable. For the lube oil cooler it points out that the proper design air temperature be used or a few degrees variation in ambient will have a tremendous effect upon the duty. On the other hand, the lube oil duty is much less affected by the lack of air. The steam condenser is not so sensitive to variation from design air temperature, but is materially influenced by insufficient air. The jacket water cooler approaches the lube oil cooler in Fig. 2, and the steam condenser in Fig. 3.

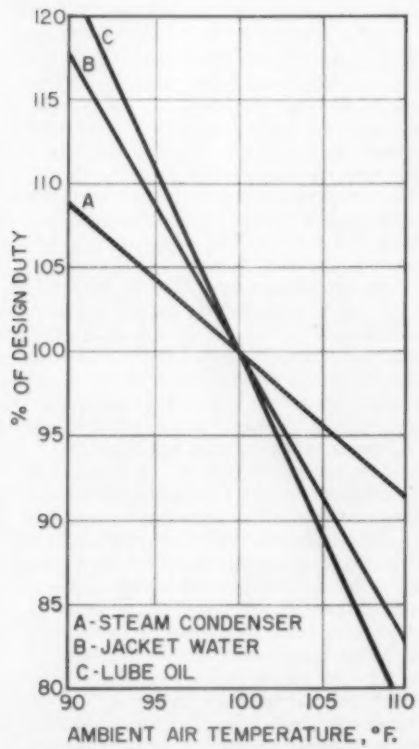


FIG. 2 CAPACITY VS. AIR TEMPERATURE

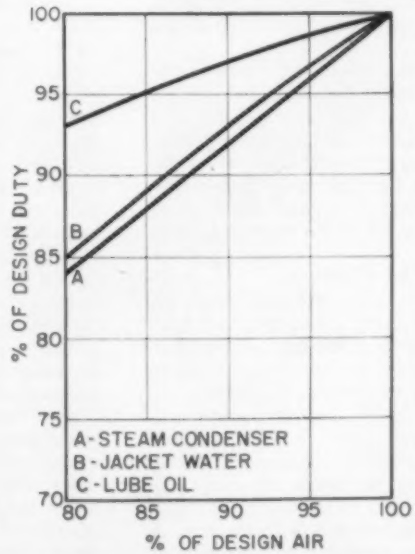


FIG. 3 CAPACITY VS. AIR DELIVERY

FANS

Axial flow fans are inherently large volume, low pressure devices. Except for special pressure blower fans which operate at static pressures above one inch of water, most axial fans presently in use operate from free discharge up to about 0.25 in. of water. Many fans with no airfoil section operate satisfactorily at low static pressures, but are not suitable for use in the intermediate or higher range. However, for use in air coolers, it is required that a fan operate at reasonably high efficiency to minimize horsepower consumption, and, at the same time, be capable of large volume displacement at static pressures of 0.25 to 1 in. of water.

In Fig. 4 are plotted three makes of fans, each with six blades, tested in a full scale cooler under identical conditions. In this particular unit normal operation is from 22 to 30,000 cu ft per min. Fans A and B obtain peak efficiency at 23,000 cu ft per min, then drop sharply, indicating maximum through-put of 29 to 31,000 cu ft per min. If more air than normal is required, then neither fan A nor B can be used. Fan C, with its broad plateau of efficiency, has not reached its maximum output at 34,000 cu ft per min. If the static pressure had been greater than expected, and the design point near 30,000 cu ft per min, the design air quantity would never be attained using Fans A or B. Fan C, with its 15 to 20 percent greater capacity would perform satisfactorily.

It is essential that the stall-out conditions be known for a fan before attempting to use it in air coolers. It was found that a four-bladed model of Fan A, when tested as the fans shown on Fig. 4, stalled-out at 22,000 cu ft per min, being unable to produce any more air regardless of power input.

Air delivery and fan performance are materially affected by the design and construction of the fan ring and plenum chamber. The air must be distributed from the circular area of the fan, at velocities of 1000 to 2000 ft per min, to the rectangular area of the finned tube coil, where the velocity approaching the face of the coil is 400 to 700 ft per min. A reasonable distance from fan to coil (plenum-chamber depth) has been found to be approximately one half of the fan diameter. If the distance is too small, there will be an area of low or no velocity through the coil directly over the fan hub, and the air distribution of the entire coil will be unsatisfactory. The overall cooling capacity will be reduced as the air distribution becomes uneven. In most installations, the ratio of fan area to coil face area is such that a plenum depth of approximately one-half of the fan diameter will allow satisfactory air distribution. Much greater depths are neither required nor are they economical.

Fan ring design should be tailored to the fan being used. Very close tip clearances are not practical to fabricate, so it is desirable to use fans which are less sensitive in their performance to substantial clearances. The depth of the fan ring is, however, critical. This fact was pointed out in a series of tests on a 5 ft diameter six-bladed, axial-flow fan with ¼ in. tip clearance, in both a 4 and 8 in. deep fan ring. With the same power consumption, the 8 in. deep ring produced from 5 to 15 percent more air. The percentage increase was proportional to the volume of air and static pressure against which the fan was operating.

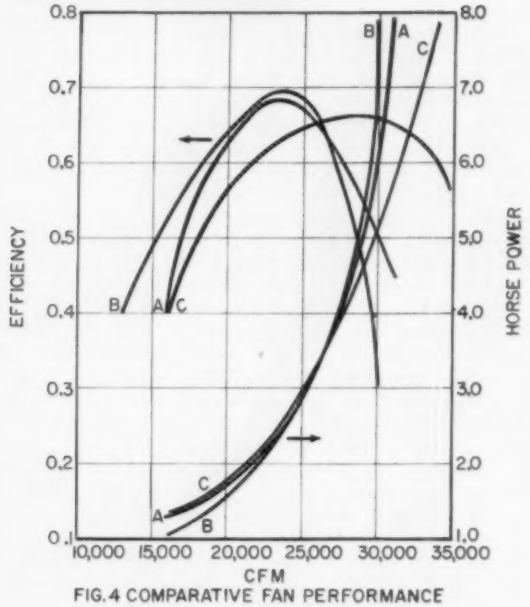


FIG. 4 COMPARATIVE FAN PERFORMANCE

PLOT LIMITATIONS

One of the problems arising with greater frequency as air coolers become more widely used is that of finding sufficient ground area for their installation. Another is the move to reduce the noise level of plants. The latter particularly affects air coolers since fans can be a source of considerable noise. Some users of air coolers have attempted to reduce the noise level of their fans by specifying a maximum tip speed less than 10,000 ft per min.

To the uninitiated the problems of plot limits and noise levels appear relatively simple. To the designer-fabricator this can present a disturbing dilemma. A plot limitation forces the designer to use more rows of tubes, that is, use a deeper finned tube coil. More rows require higher static pressures if reasonable air volumes are to be used. Higher static pressures may be obtained from fans by using high blade-angle settings, up to a point, beyond which they may be obtained only with high tip speeds. High tip speeds cause the noise level to rise.

It is not usually possible to obtain the required air delivery with present day design while using fan tip speeds under 10,000 ft per min. Part of this problem is being solved by elevating the air cooled structures over pipe racks, buildings, and other essentially low and stable construction, which do not dissipate much heat to the atmosphere. This increases the available plot area permitting use of reasonable fan-tip speeds with some reduction in noise at the operating level.

SPECIFICATION FORM

A representative form used for the specification of air fin coolers is shown in Fig. 5. As in other types of heat exchangers, **a complete description of the tube side fluid is required.** Normal usage dictates that the process information for the fluid to be cooled be set forth by the purchaser.

The selection of the proper design ambient air temperature, however, is often open to discussion. It is obvious that the maximum ambient air temperature experienced cannot economically be used for design purposes. Therefore, an economic balance between the cost of the equipment at a given design air temperature be balanced with the loss of product or product cooling experienced at temperatures above the design ambient air. Many users have found it

FOR — ITEM NO.
DESTINATION — PROPOSAL NO.
APPARATUS — DATE

PERFORMANCE

HOT FLUID IN TUBES

CHARACTER	QUANTITY
MW	
API GRAVITY	TEMPERATURE IN, °F.
SPECIFIC GRAVITY @ 60°F.	TEMPERATURE OUT, °F.
SPECIFIC HEAT @ °F.	WORKING PRESSURE, PSI
VISCOSITY @ °F.	PRESSURE DROP, PSI
FOULING FACTOR	LIQUID CONDENSED
HEAT TRANSFERRED, BTU/HR	
OVERALL TRANSFER RATE, BTU/HR/SQ. FT. BARE TUBE SURFACE/°F.	
MTD °F.	

COLD FLUID OVER TUBES

CHARACTER ATMOSPHERIC AIR	QUANTITY, LB./HR.
ELEVATION, FT.	TEMPERATURE IN, °F.
	TEMPERATURE OUT, °F.

CONSTRUCTION

FINTUBE SECTIONS

NUMBER	TUBES, TYPE
CONNECTED	SIZE
SIZE	LENGTH
SURFACE/SECTION, SQ. FT.	NUMBER/ROW
SURFACE TOTAL, SQ. FT.	SPACING
DESIGN TEMP., °F.	MATERIAL
DESIGN PRESSURE, PSI	FIN MATERIAL
TEST PRESSURE, PSI	FIN THICKNESS
NUMBER PASSES	HEADERS, TYPE
NUMBER ROWS TUBES	MATERIAL
INLET NOZZLE	TUBE PLUGS
OUTLET NOZZLE	FOULING

FANS

TYPE	DRIVE:
NUMBER	
SIZE	MOTORS:
NUMBER BLADES	
BLADE MATERIAL	RPM
FAN RPM	HP
INPUT HP/FAN	POWER
INPUT HP TOTAL	

STRUCTURE

TYPE	FINISH
NUMBER BAYS	MARKED FOR ASSEMBLY
DESIGN WIND LOAD, LB./SQ. FT.	ASSEMBLY BY
PREFABRICATION	CONSTRUCTION

MISCELLANEOUS

FIG. 5. Proposed specification form.

advantageous to use the same general approach in designing air coolers that they use in designing cooling towers (i.e., for something less than the maximum ambient temperatures experienced). The basic problem is virtually the same, differing only in the magnitude of the cost of the two different types of equipment involved. The extensive atmospheric temperature data available today, for most localities where air cooled equipment might be installed, will enable the possible user of such equipment to make a close approximation of the total number of hours during a given period at which he will be operating above the design ambient air temperature. Frequently an extensive study is not dictated if the user has at least a limited experience in the use of air fin coolers. But, for the new or uninitiated, it may be necessary to work closely with a supplier of such equipment in order to gain the experience to cope with the problem.

If the user has a plot limitation for given duties, he will find it advantageous to so state in his specifications. With no plot limitations, the fabricator will ordinarily attempt to reach an economic balance between the number of rows of tubes and the plot dimensions. This will at the same time, include a reasonable horsepower selection, which might not be feasible if a limited plot plan must be adhered to.

In most instances a minimum number of fans and drives is the most economical. If, however, extensive control of the process fluid temperature is required, it should be so stated in the specifications, so that an adequate number of fans, louvers, and any additional control equipment necessary may be included in the basic design.

The foregoing discussion has been set forth only as an aid to those engineers who, through lack of opportunity for experience in this particular field, find it necessary to acquaint themselves with air fin cooler specifications. A detailed discussion of methods of thermal rating and mechanical design have been intentionally avoided because of the lengthy discussion required to cover either subject.

★ ★ ★

How to Specify Centrifugal Pumps

W. J. Evers **E. E. Ludwig**
The Dow Chemical Company
Freeport, Texas

In specifying a pump, care must be taken to avoid pyramiding safety factors by being too generous with . . .

- **Design Capacity**
- **Friction Drops**
- **Control Valve Pressure Loss**
- **Rating Head over Calculated Head**

LIQUID HANDLING EQUIPMENT constitutes a major portion of the investment for a processing plant. It is vitally important that care be taken in sizing the key components of a fluid flow system, namely, lines and pumps. It is difficult to divorce the two and a typical line sizing sheet (Fig. 2) is given for use in the discussion.

DESIGN DATA

Consider the simple pump system shown in Fig. 1. The calculated flow is 55 gal per min, but since the stream contains a level control valve, a design rate of 75 gal per min is used. If the stream were flow controlled, the margin between design and calculated flows would be reduced.

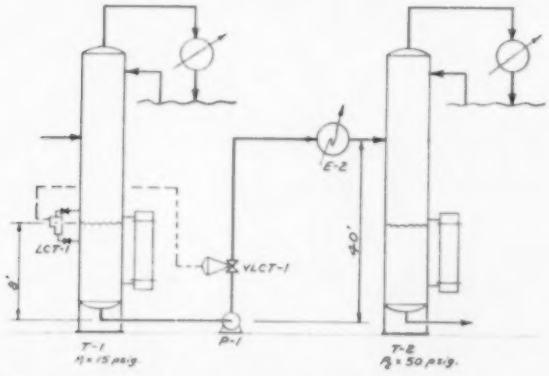
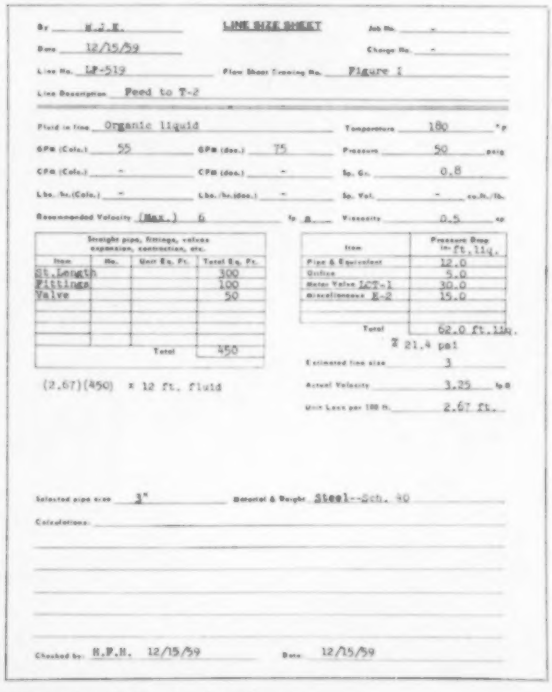


FIG. 1. Schematic diagram of a simple pump system.

The elevation to the normal liquid level of 8 ft is entered on the pump specification sheet. Tower, T-1, operating pressure of 15 psig is converted to feet of fluid and the friction drop in the pump suction line is obtained from a line sizing sheet similar to Fig. 2. Static and operating heads for the pump discharge side are entered and the friction head loss of 62 ft taken from Fig. 2.

Total differential head of 197 ft is obtained and a safety factor applied, giving a rating head of 210 ft. This rating head will reflect the uncertainty in the head capacity relationship for the system. In the case of a controlled flow as in the sample, over generosity of this safety factor results in extravagant power use since the additional head that the pump develops is absorbed by additional pressure drop across the control valve.

Consider this system without automatic control. Head generally increases with capacity on system head curves and decreases with capacity on pump operating curves. The pump will operate at a capacity greater than specified due to actual head being lower than specified. This type of operation can result in adverse conditions such as motor overload, cavitation, erosion, and eventual destruction of the pump.


LINE SIZE SHEET

By H.J.E. Job No. -
Date 12/15/59 Change No. -
Line No. LP-519 Flow Sheet Drawing No. Figure 1
Line Description Feed to T-2

Fluid in line Organic liquid Temperature 180 °F
GPM (Calc.) 55 GPM (des.) 75 Pressure 50 psig
CFM (Calc.) - CFM (des.) - Sp. Gr. 0.8
Lbs./hr.(Calc.) - Lbs./hr.(des.) - Sp. Vol. - cu.ft./lb.
Recommended Velocity (Max.) 6 to 8 Viscosity 0.5 cp

Straight pipe, fittings, valves expansion, contraction, etc.

Item	No.	Unit Eq. Ft.	Total Eq. Ft.
St. Length			300
Fittings			100
Valve			50
		Total	450

Item	Pressure Drop in ft. liq.
Pipe & Equivalent	12.0
Orifice	5.0
Motor Valve LCT-1	30.0
Miscellaneous E-2	15.0
Total	62.0 ft. liq.

≙ 21.4 psi

(2.67)(450) × 12 ft. fluid

Estimated line size 3
Actual Velocity 3.25 fps
Unit Loss per 100 ft. 2.67 ft.

Selected pipe size 3" Material & Weight Steel--Sch. 40
Calculations:

Checked by H.P.H. 12/15/59 Date 12/15/59

FIG. 2. Sample line size data sheet.

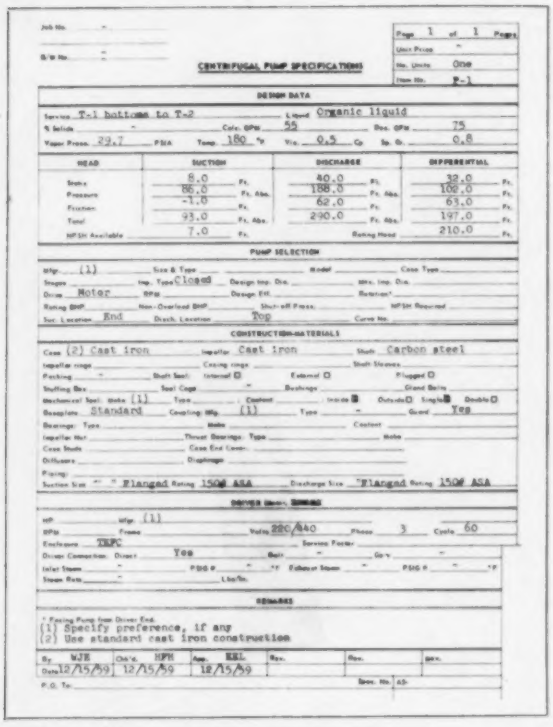
If this pump fed two or more parallel systems, the branch with the highest total discharge head would be specified. The pressure drop in the other branches would be equalized by increasing the control valve pressure drop to take up the difference. For example, if pump, P-1, fed another branch with a total discharge of 320 ft absolute instead of the 290 ft shown in Fig. 3, the pressure drop for design of LCT-1 should be increased 30 ft and the new pressure drop for LCT-1 would be 60 ft.

Net positive suction head (NPSH) is liquid head available at the eye of the impeller to prevent vaporization of the liquid. Thus, from Fig. 3:

NPSH = Pressure above liquid – vapor pressure + static head – friction loss =

86 – 86 + 8 – 1 = 7 ft available

The NPSH of 7 ft is reasonable for this capacity. When a boiling liquid results in low NPSH available, consideration should be given to increasing vessel skirt heights to avoid having to purchase larger and more expensive pumps with low NPSH requirements.



CENTRIFUGAL PUMP SPECIFICATIONS

Page 1 of 1 Pages

DESIGN DATA

Service T-1 bottoms to T-2 — Liquid Organic liquid

Color, GPM 55 — Des. GPM 75

Vapor Press. 29.7 — PSIA — Temp. 180 °F — Vis. 0.5 Cp — Sp. Gr. 0.8

HEAD	SUCTION	DISCHARGE	DIFFERENTIAL
Static	8.0 Ft.	40.0 Ft.	32.0 Ft.
Pressure	86.0 Ft. Abs.	106.0 Ft. Abs.	106.0 Ft.
Friction	-1.0 Ft.	62.0 Ft.	63.0 Ft.
Total	93.0 Ft. Abs.	290.0 Ft. Abs.	197.0 Ft.
NPSH Available	7.0 Ft.	Rating Head	210.0 Ft.

PUMP SELECTION

Mfgr. (1) — Size & Type — Model — Case Type

Stages — Imp. Type Closed — Design Imp. Dia. — Min. Imp. Dia.

Drive Motor — RPM — Design Eff. — Rotation*

Rating BHP — Non-Overload BHP — Shut-off Press. — NPSH Required

Suc. Location End — Disch. Location Top — Curve No.

CONSTRUCTION MATERIALS

Case (2) Cast iron — Impeller Cast iron — Shaft Carbon steel

Impeller rings — Casing rings — Shaft Sleeves

Packing — Shaft Seal: Internal ☐ External ☐ Flagged ☐

Stuffing Box — Seal Cage — Bushings — Gland Bolts

Mechanical Seal: Make (1) Type — Gasket — Inside ■ Outside ☐ Single ■ Double ☐

Gaskets Standard — Cooling Mfg. (1) Type — Guard Yes

Bearings: Type — Make — Coolant

Impeller Nut — Thrust Bearings: Type — Make

Case Studs — Case End Cover

Diffusers — Diaphragm

Piping:

Suction Size 8" Flanged Rating 150# ASA — Discharge Size 6" Flanged Rating 150# ASA

DRIVER (Mfgr. Data)

HP — Mfgr. (1)

RPM — Frame — Volts 220/440 — Phase 3 — Cycle 60

Enclosure TEFC — Service Factor

Driver Connection: Direct Yes — Gear — Gov't

Inlet Steam — PSIG # — °F — Exhaust Steam — PSIG # — °F

Steam Rate — Lbs/hr.

REMARKS

* Facing Pump from Driver End.
(1) Specify preference, if any
(2) Use standard cast iron construction

By	WJE	Chk'd.	HPH	App.	EKL	Rev.	Rev.	Rev.
Date	12/15/59		12/15/59		12/15/59			

P.O. To — Spec. No. AS-

FIG. 3. Sample centrifugal pump specification sheet.

PUMP SELECTION

The majority of the items in this section of the specification sheet are dependent upon the final selection of the vendor and pump model. A few should be indicated beforehand to guide the vendor in his selection.

For clear liquids, a closed type impeller is invariably used. An open type impeller is desirable for streams containing solids.

Impeller diameter will depend on the pump selected. The vendor's selection should be checked to avoid using a pump with a maximum-sized impeller when future increases in capacity may be anticipated.

It may be desirable to specify type of drive, direct or belt, and the speed of the pump. For solid suspensions it may be desirable to specify a maximum speed of 1750 rpm.

Since the piping and layouts may precede the final pump selection, a definite configuration of suction and discharge location is often desirable.

CONSTRUCTION AND MATERIALS

The customer often specifies the materials of construction to conform to the service requirements. If the composition of the stream to be pumped can be given, the vendor's standard materials for this service may be acceptable and more economical.

The customer usually specifies the type of shaft seal, depending on process limitations. The type of coupling, or coupling manufacturer, should be given to correspond to customer's existing units. Some of the other mechanical features may be spelled out to meet specific requirements or customer's standards, but the majority could be open to the vendor to take a price advantage of his standards.

DRIVER

The type of drive should be given with the corresponding power characteristics or steam conditions. It should be indicated if driver is to be nonoverloading. It may be desirable to size the motor for the next larger impeller size.

The type of motor desired, such as TEFC, explosion-proof, open, TENV, etc., should be specified according to the requirements of the electrical classification determined by the process conditions and surroundings.

It must be remembered in determining the power requirements that the capacity-head relationship is independent of specific gravity, but the power curves are usually for water and must be multiplied by the specific gravity to obtain the motor requirements for a particular fluid.

The effect of viscosity upon power requirements must be considered since a correction factor must be applied to efficiency, head, and capacity for highly viscous fluids. These corrections are normally handled by the pump vendor.

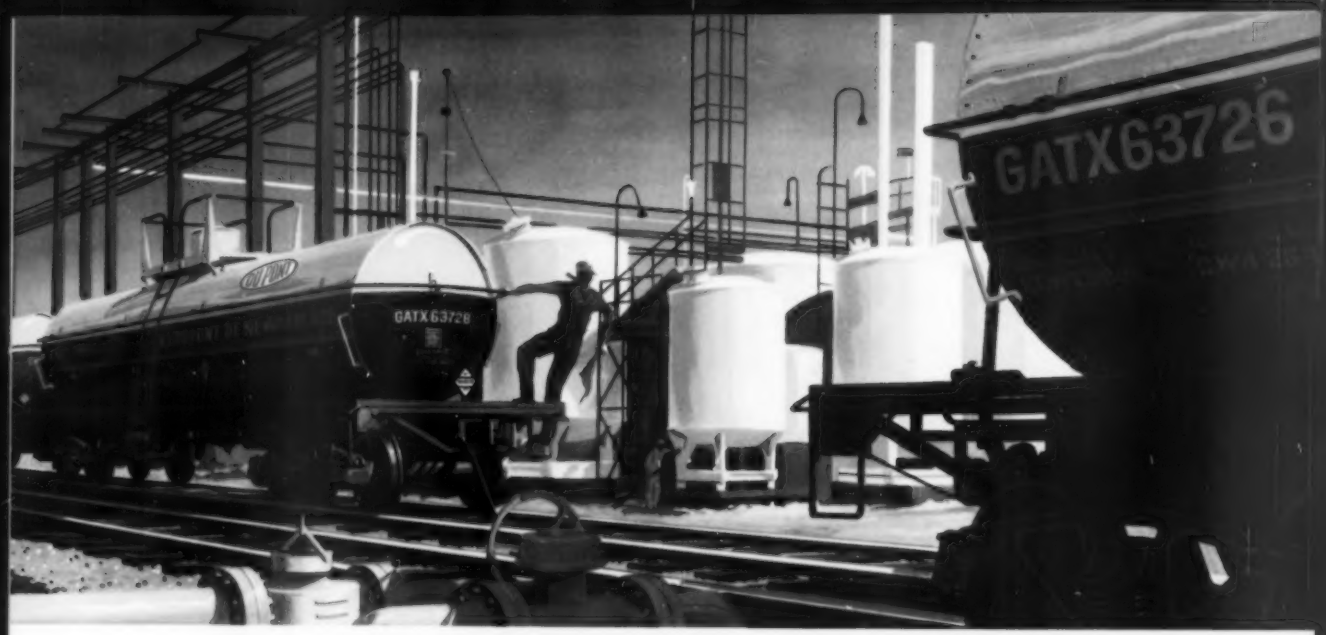
CONCLUSIONS

In specifying a pump, care must be taken to avoid pyramiding safety factors by being too generous with (1) design capacity over calculated, (2) control valve pressure drops, (3) friction drops, and (4) rating head over calculated head. The NPSH available should be clearly identified.

It may be quite helpful in specifying a pump to make a tentative selection of a particular vendor, type, and model to facilitate checking overloading, standard materials of construction, and other details. From the tentative selection it can be decided if a vertically-split-case pump is suitable, or if the more expensive horizontally-split-case is required. Many of the mechanical features of the pump cannot be set until final selection is made. ★ ★ ★

Mr. Evers *received his BS in Chemical Engineering in 1949 at the University of Illinois, and his MS degree in Ch. E. in 1950 at Northwestern University. He joined the Ethyl Corporation at Baton Rouge, Louisiana in October 1950 and was in Process Engineering, Technical Services until February 1953 when he turned his services to the Union Carbide Nuclear Company, Oak Ridge, Tennessee, as Project Engineer. In December 1955 he came to Texas, as Process Engineer with The Dow Chemical Company, Process Engineering, Freeport, Texas. He is a member of the American Institute of Chemical Engineers, Sigma Xi, and Phi Lambda Upsilon, and a registered Professional Chemical and Mechanical Engineer in the State of Texas.*

Mr. Ludwig *received his BS at the University of Texas, and his MS in Chemical Engineering from there in 1942. He joined Dow's Texas Division in 1942, and served as Chemical Process Engineer, Assistant Engineering Manager, and as Process Engineering Manager — all concerned primarily with process and project work for new organic and inorganic chemical plant design and construction. He is a member of the American Institute of Chemical Engineers, American Chemical Society, and is a registered Professional Chemical and Mechanical Engineer in the State of Texas.*



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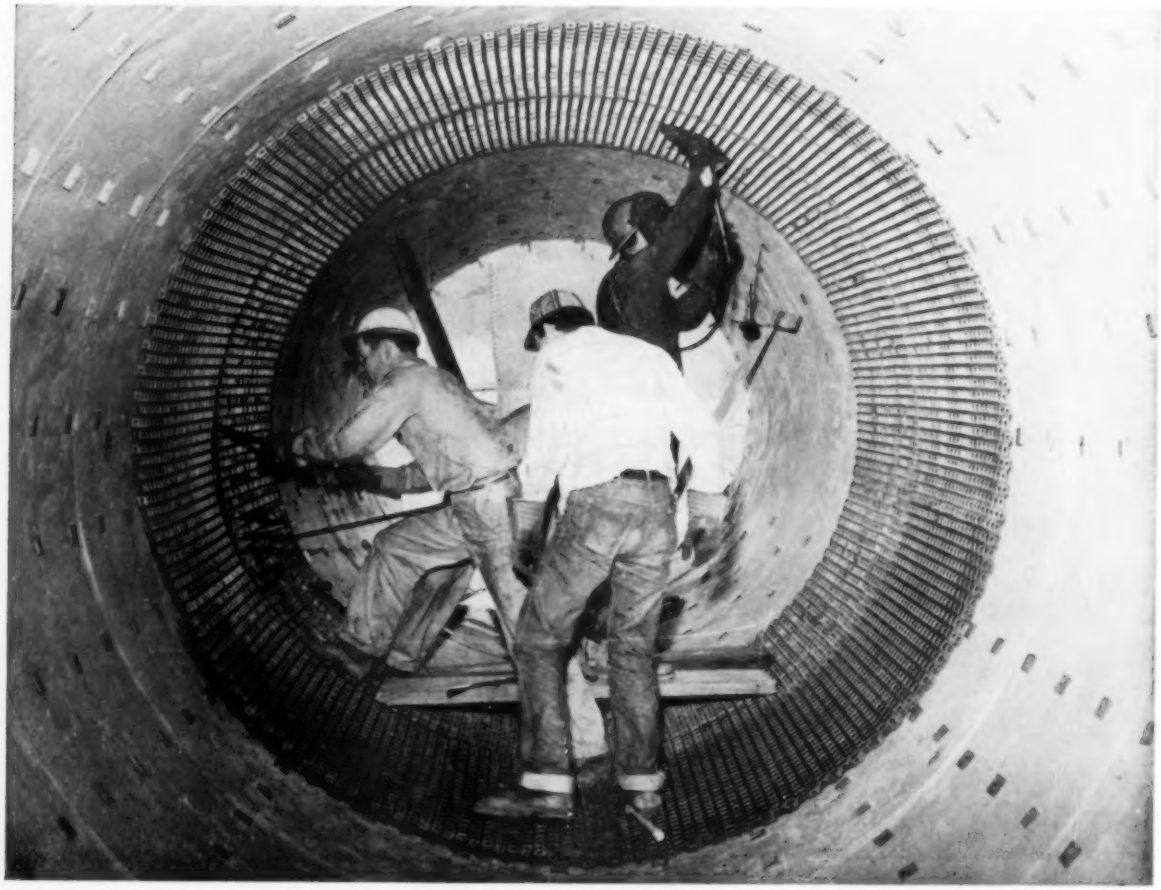

Gunite Contractor: J. A. McCollum, Inc., Marlton, N. J. Castables: Kaiser Refractories & Chemicals Div.

In this catalyst line at a large Gulf Coast refinery, steel mesh is being welded into place over a 3-inch lining of refractory insulating concrete made with LUMNITE calcium-aluminate cement. Over the mesh, a 1-inch thickness of high-strength castable will be gunited, providing a 2-component refractory concrete lining that will resist severe erosion and abrasion caused by catalyst fines. Monolithic refractory concrete linings eliminate troublesome mortar joints. They are easily placed, conforming to any contour. Castables are recommended because they are simply mixed with water and placed – concrete reaches service strength in 24 hours. Castables containing LUMNITE cement are available from leading manufacturers of refractories for a variety of applications in refinery equipment. For information, write Universal Atlas Cement, 100 Park Avenue, New York 17, N. Y.

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DISTILLATION . . .

in View of Modern Developments

a series on recent developments in distillation and absorption techniques

Part II: Distillation
Chapter 2 — Theory of Fractionation
a — Degrees of freedom

Kenneth F. Gordon
University of Michigan
Ann Arbor, Michigan

James A. Davies
Texaco Inc.
New York City

IN THE DESIGN of separation processes such as in distillation it is desirable to know the degrees of freedom; that is, the number of design variables that must be arbitrarily set to fix the whole system.

With the advent of high speed computation methods complex problems are now amenable to exact numerical solution within the accuracy of the available data. The effect of a change in one or several variables can be determined exactly without undue effort once a computer program is available. It is now necessary to know how many variables in a process are truly independent. This chapter will show how this may be done systematically for distillation columns and indicate the approach for a situation involving a number of columns, heat exchangers and pumps.

Gilliland and Reed[1] have discussed this problem with respect to distillation columns, while recently Kwauk [2] has given a generalized method. His more formal method, which is presented here, has the advantage of being systematized and readily used on a broader scope of problems.

Definition of Variables

The mode of attack is simple in principle. The degrees of freedom or independent variables, N_i, is the total number of variables, N_v, less the constraining equations, N_c. Here the dictates of elementary algebra are followed.

$$N_i = N_v - N_c$$

N_v = total variables = phase rule (intensive) variables plus number of rates of flow of total phase plus rates of flow of heat to or from the system.

$$= N_{\text{phase rule}} + N_{\text{flow}} + N_Q$$

For one phase

$$N_{\text{phase rule}} = C + 2 - P = C + 1$$
$$N_{\text{flow}} \qquad\qquad 1$$
$$\qquad\qquad C + 2$$

For two phases in equilibrium, flows independent

$$N_{\text{phase rule}} = C + 2 - 2 = C$$
$$N_{\text{flow}} \qquad\qquad 2$$
$$\qquad\qquad C + 2$$

N_c = number of constraining conditions or equations. They are of the following types:

1. Material Balance,
2. First Law of Thermodynamics or Energy Balance,
3. Equations or conditions such as those showing the equality of composition, temperature and amount of the streams counted twice such as a stream leaving one plate and entering the adjacent plate. This particular stream is counted twice, once as it leaves a plate and as it enters the next.

Usually a number of conditions, N_x, are set or used by design. These are composition, amount and condition of the feeds, N_F; pressure on each plate, N_π; and heat leak on each plate, N_Q.

$$N_x = N_F + N_\pi + N_Q$$

The number of process variables that may be arbitrarily set to define a system is the number of variables available to the designer, N_a. This is also known as the degrees of freedom.

$$\begin{aligned} N_a &= N_i - N_x \\ &= \text{Total variables} \\ &\quad - \text{Variables Constrained} - \text{Variables Used} \\ &= N_v - N_c - N_x \\ &= N_v - N_c - N_F - N_\pi - N_Q \end{aligned}$$

To prevent errors it is necessary to have a consistent systematic approach. As in the definition of variables in the application of the phase rule where there may be several routes, no trouble will result if a definite nomenclature is used.

Definitions of Sections of a Complex Unit

A complex unit such as a plant or petroleum fractionator with distillation columns on side drawoff streams may be broken down into units such as distillation columns. The units may be further broken into complex elements such as a multiplate stripping section and multiplate rectifying section, feed plates, drawoff plates, reboiler and condenser. The complex elements such as a n-stage or n-plate stripping section may be broken into n elements each of one stage or plate. A feed plate can be broken into the elements of a mixer and an ordinary plate.

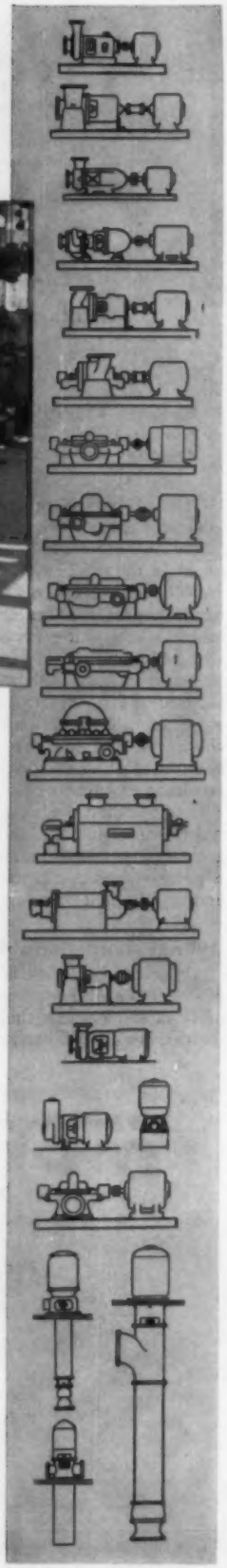
Elements (e)

Let an appropriate superscript refer a variable to one of the classes such as unit or element mentioned above. Thus, N_i^e would be the number of independent variables for an element.

$$N_i^e = N_v^e - N_c^e$$

Consider a theoretical plate. The two entering single phase streams each have $C + 2$ total variables, phase rule

HOW TO PICK A WINNER IN THE "OCTANE RACE"



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● **OPERATING COSTS** depend not only on published performance curves, but on *sustained* high efficiency. And I-R pumps have built their reputation on long-term efficiency, with running clearances that can be maintained for years without frequent replacement of parts.

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Nomenclature

C	Number of components
N	Number of variables
n	Number of plates
P	Number of phases

Subscripts

a	Available variables for specification
c	Constraining conditions
F	Feed
i	Independent
Q	Heat
v	Total
x	Normally used
α	Repetitions of elements
π	Pressure

Superscripts

e	Element
E	Complex element
u	Unit

plus rate of flow, for a total of $2(C + 2)$. The two streams leaving in equilibrium represent $C + 2$ variables, incidentally setting the pressure. Here the amount of each stream is taken as independent and a constraining material balance equation will be introduced shortly. Another variable is the heat exchange with the surroundings

$$N_v^e = 2(C + 2) + (C + 2) + 1 = 3C + 7.$$

The constraining equations for this single plate are C material balances, one for each component and one energy balance which in almost all cases is a heat balance.

$$N_c^e = C + 1$$

$$N_i^e = N_v^e - N_c^e = 2C + 6$$

The fixed variables set by design for this plate are the composition and flow rates of the two feeds, $2(C + 2)$, the pressure on the plate, (1), and the heat exchange or leak, (1).

$$N_x^e = N_F^e + N_\pi^e + N_Q^e$$

$$= 2(C + 2) + 1 + 1 = 2C + 6$$

The number of variables available is given by

$$N_a^e = N_i^e - N_x^e = (2C + 6) - (2C + 6) = 0$$

That is by defining the feed streams, plate pressure and heat loss, the amount and condition of the product streams of a single plate are set. This obvious result is quite clear without the analysis. However, in more elaborate devices the result cannot be seen immediately, but must be gained from a detailed analysis as is given in the remainder of this section.

Complex Elements (E); Example, Absorption Column

An example of a complex element is a section of n stages of n identical elements.
Here, using superscripts ^{E},

$$N_a^E = N_i^E - N_x^E$$

$$N_i^E = N_v^E - N_c^E$$

A complex element is a summation of elementary elements. One more variable has been added; namely, the number of elements to the complex element.

If n elements, say plates, are combined, the total number of variables, $N_v^{E'}$, will be given by

$$N_v^{E'} = \Sigma N_v^e + N_\alpha$$

where N_α is the number of variables which designates the number of times the element is repeated. In a n-stage stripping column only one variable, n, is needed to designate the number of plates. Therefore, $N_\alpha = 1$.

We could let the two streams leaving one plate in equilibrium possess $C + 2$ variables and each of the two entering streams possess $C + 2$ variables. Each plate has the heat exchange variable for a total of $3C + 7$ variables as given above in the discussion of elements.
Then,

$$N_v^{E'} = \Sigma N_v^e + N_\alpha$$

$$= n(3C + 7) + 1$$

But there really aren't that many free variables, for each element has $N_c^e = C + 1$ constraining equations and the number of variables is given by

$$N_v^E = N_v^{E'} - \Sigma N_c^e = \Sigma N_v^e - \Sigma N_c^e + N_\alpha = \Sigma N_i^e + N_\alpha$$

$$= n(3C + 7) + 1 - n(C + 1) = n(2C + 6) + 1$$

The complex element has some constraining equations. Those are the equations relating the composition of the interstreams. For each single phase stream there are $C + 2$ variables. The stream leaving one plate and entering the adjacent plate has been counted twice, once as a leaving stream and once as an entering stream, each of $C + 2$ variables. We have the equations of equality of amount of each component, temperature and pressure. This gives $C + 2$ equations per stream for the $2(n - 1)$ interstreams.

$$N_c^E = 2(n - 1)(C + 2)$$

$$N_i^E = N_v^E - N_c^E = 2C + 2n + 5$$

For each plate the designer normally sets the heat leak and pressure which are included in N_i. The number of variables in the complex element which is fixed by design is obtained from a consideration of the feed variables to the complex element, N_F^E, and the heat leak and pressure variables of each plate or element.

$$N_x^E = N_F^E + \Sigma (N_x^e - N_F^e) = N_F^E + \Sigma (N_Q^e + N_\pi^e)$$
$$\Sigma (N_Q^e + N_\pi^e) = 2n$$

The two feed streams to the sections each have $C + 2$ variables

$$N_F^E = 2(C + 2)$$

$$N_x^E = 2(C + 2) + 2n$$

The degrees of freedom then are

$$N_a^E = N_i^E - N_x^E = 1$$

For two given feeds we have one degree of freedom in the multiplate section. When the number of plates is set then all is specified and the products determined if the

pressure and heat leak on each plate is preset. Theoretically, we can gain degrees of freedom by allowing plate pressures and heat leaks to vary.

Unit (u)

A unit such as a distillation column consists of five parts, the stripping and rectifying sections, the feed plate, condenser and reboiler.

Calling elements and complex elements minor classes and units and combinations of units major classes and letting superscript ^{u} refer to a major class,

$$N_a^u = N_l^u - N_x^u$$

where $N_l^u = \underset{\text{minor}}{\Sigma} N_l + N_e - N_c^u$

and $N_x^u = N_F^u + \underset{\text{minor}}{\Sigma} (N_x - N_F) = N_F^u + \underset{\text{minor}}{\Sigma} (N_r + N_Q)$

Also $N_r^u = \underset{\text{minor}}{\Sigma} N_l + N_e$

N_e = the number of times component classes are repeated, or the number of times we can make choices of n, where n is the number of elements in a complex element.

Example, Distillation Column

$$N_r^u = \underset{\text{minor}}{\Sigma} N_l + N_e$$

$N_e = 0$ since no complex element class is repeated, the N_e for the n-plate contactor being absorbed in the N_l of the minor class

1. Reboiler:

N_r^e = One feed stream (C+2), +temperature (or pressure) (1) + heat flux (1) + 2 equilibrium exit streams (C + 2).

$= 2\,(C + 2) + 2$

N_c^e = Material balances (C), heat balance (1) and latent heat relation between heat (or energy) in and phase change in streams (1).

$= (C + 2)$ equations

$N_l^e = N_r^e - N_c^e = C + 4$

2. Condenser: Similarly, $N_l^e = C + 4$

3. & 4. Multiplate contactors of the rectifying and stripping sections of n_1 and n_2 plates.

From the section on elements $N_l^E =$

$[2C + 2n_1 + 5] + [2C + 2n_2 + 5]$

5. Feed plate: A feed plate may be regarded as a mixer, where the single phase feed is mixed with the appropriate stream entering the plate, plus an ordinary plate. The mixer has 2 entering streams and 1 leaving, each with (C + 2) variables, and one heat flux variable. There are C material balances and one energy balance. Thus, $N_l^e = [3(C+2)+1] - [C+1] = 2C+6$ variables. For an ordinary plate as discussed above, $N_l^e = 2C + 6$.

The stream leaving the mixer and the stream entering the ordinary plate are identical and related by C + 2 equations.

For the feed plate,

$$N_l^E = (2C + 6) + (2C + 6) - (C + 2) = 3C + 10.$$

For the distillation column:

$$N_r^u = \underset{\text{minor}}{\Sigma} N_l + N_e$$

$$= 2(n_1 + n_2) + 9C + 28$$

There are eight interstreams between the five minor classes, reboiler, feed plate, etc.

$$N_c^u = 8\,(C + 2)$$

$$N_l^u = N_r^u - N_c^u = 2(n_1 + n_2) + C + 12$$

The normally fixed variables of the minor classes are:

1. Reboiler $= N_Q + N_{T \text{ or } \pi} = 2$
2. Condenser $= N_Q + N_{T \text{ or } \pi} = 2$
3. & 4. Multiplate Contactor:

stripping and rectifying section $=$
$(N_Q + N_r) = 2\,(n_1 + n_2)$

5. Feed plate

$$= N_Q + N_r = 2$$

For the distillation column

$$\Sigma(N_x^E - N_F^E) = \Sigma(N_Q + N_r) = 2(n_1 + n_2) + 6$$

$$N_F^u = C + 2$$

$$N_x^u = N_F^u + \Sigma(N_x^E - N_F^E)$$
$$= C + 2 + 2(n_1 + n_2) + 6$$

$$N_a^u = N_l^u - N_x^u = 4$$

Usually the pressure and heat flux on each plate is fixed by the designer. The pressures in the condenser and reboiler are also fixed. The heat flux in the condenser and boiler are usually fixed to handle all the material which arrives. From the analysis it is seen that for any distillation column, of any number of components, only four variables or degrees of freedom remain.

This is something that one might arrive at by experience or from an analysis for a two component system but not by experience for a multicomponent system.

The four variables are usually taken up as follows. Two by specifying two recoveries or two concentrations or two concentration ratios. These normally refer to the keys, one for the distillate and one for the bottoms. The third variable is a specified reflux ratio, while the fourth is a little more subtle. It is that the total number of plates be a minimum through optimum location of the feed plate. Again it is to be noted that extra degrees of freedom are possible by varying the pressure in the column, even operating the stripping section at one pressure and the rectifying section at another employing intermediate pumps or compressors, or by changing the temperature of the feed.

The same mode of development can be expanded to include pumps, heat exchangers, twin azeotropic distillation columns and chemical plants.[2]

References

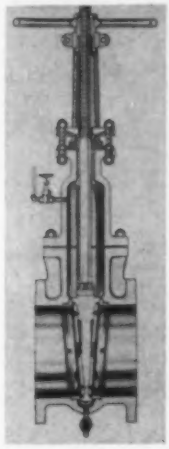
1. Gilliland, E. R. and C. E. Reed, *Ind. Eng. Chem.*, 34, 551 (1942).
2. Kwauk, M., *AIChE Journal*, 2, 240 (1956).

It's New

Refining - Processing Equipment

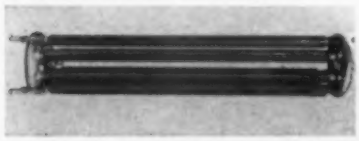
Block-Bleed-Test Valves

New Block-Bleed-Test valves feature dual metal-to-metal and elastomer seals. A simple visual proof test upon each closure of the valve permits the operator to verify the effectiveness of seat tightness. Designed to outmode the use of auxiliary line blinds, this non-lubricated gate valve will perform efficiently and economically in services handling light gases or heavy fluids within a temperature operating range of —40 deg F to +400 deg F. Absolute shut-off promotes operational safety and eliminates the possibility of product contamination. Valves utilizing Vitron "A" elastomer as the secondary seal are recommended for a majority of services handling lubricants, fuels and hydraulic fluids, and a wide range of industrial chemicals. *Pacific Valves, Inc.*



Circle number (41) on reply card.

Storage Tank Heaters

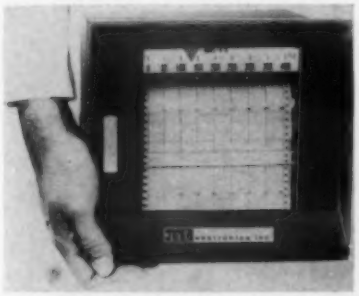


A new heavy duty finned tank heater that helps overcome the corrosion problems confronting plants that must use poor quality steam has been developed for bulk storage tanks. *Brown Fintube Co.*

Circle number (42) on reply card.

A Recording Potentiometer

A recording potentiometer which will allow the plotting of a number of variables by scanning and sampling has been newly



released. Each variable is identified at its position on the chart by means of a number or a number and a point, printing with multiple or single colors. *Westronics, Inc.*

Circle number (43) on reply card.

Vanadium Tubing

Successful experimental extrusion of commercially pure vanadium tubing, a metal particularly suited for chemical and process plant applications has been announced. Seamless vanadium tubing should be particularly valuable in the nuclear and process industries because of the unusual combination of light weight, high temperature strength, and corrosion resistance. Until recently, vanadium could not be extruded because the impure form available was too brittle. The cost of commercially pure vanadium was several hundred dollars per pound a few years ago, but its price is currently $35 per lb. Since vanadium oxide is produced as a by-product in uranium refining, it is in excess supply and further price reductions can be expected. *Wolverine Tube Division Calumet & Hecla, Inc.*

Circle number (44) on reply card.

New Chemical Compound

A new chemical compound, Nullifire, for extinguishing gasoline and fuel oil fires has been developed. Exhaustive tests conducted over a period of several months at the Boston Fire Department Training School have demonstrated that a 2 percent solution of Nullifire, introduced through an eductor into the water stream, extinguished fuel oil fires in one-third the time of water fog and faster than either carbon dioxide or mechanical foams. *Daniel Chemical Corp.*

Circle number (45) on reply card.

Tubela Bender

Tubela Bender is a precision-built unit of great ruggedness made of all steel. Ram develops 8 tons of pressure through the manual hydraulic pump. Bending dies are finished to a close fit on the pipe for extra quality bends. Rapid power return stroke withdraws the work from the tight fitting dies. Machine and 6 sets of bending dies: ½, ¾, 1, 1¼, 1½, and 2 in. (to iron pipe standards) plus a straightening shoe come packed in a strong metal case. Other ram benders to 18 in. diam available. *Wallace Supplies Manufacturing Company.*

Circle number (46) on reply card.

Seamless Steel Tube

Integral finned low carbon and alloy seamless steel tube with improved heat transfer characteristics over previous finned tube has been added to seamless steel tube products line.

Development of new high-speed, high-pressure roll fin extruding equipment has made it possible to economically produce integral finned seamless steel tube that is specifically designed for use in shell and tube heat exchangers. Without alteration of normal fabricating procedures in the manufacture of such equipment, this tube increases the shell side surface area more than 2½ times. The finned tube is furnished with plain ends for rolling into tube sheets with the OD of the plain end and the finned portion being the same. Tube OD from ½ to 1 in. can be furnished with wall thickness of .035 in. and heavier. *Michigan Seamless Tube Company.*

Circle number (47) on reply card.

New Proportioning Pump

A new, low cost, electrically-driven Chem-O-Feeder for the accurate proportioning of concentrated corrosive chemicals has been announced. *B-I-F Industries, Inc.*

Circle number (48) on reply card.

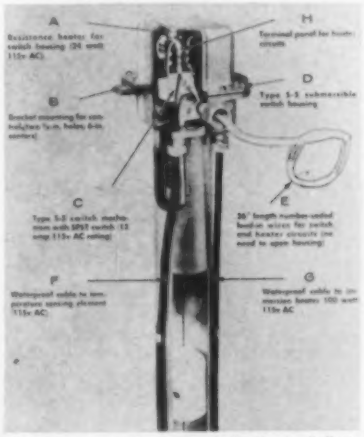
Heat Exchangers

New standard and regenerative Pyrex brand shell and tube heat exchangers with 60 sq ft capacity have been introduced. The units are designed for processing corrosive fluids. *Corning Glass Works.*

Circle number (49) on reply card.

Liquid Level Control

A new "No-Freeze" Liquid Level Control ("Winter-Proofed" Model A-101) is a new product release expected to greatly assist in dethroning King Winter insofar as outdoor water storage tanks are concerned. Should the weather turn cold and a temperature of 35 F be reached in the water in the aluminum tube around the



displacers, a thermoswitch "cuts in" to supply current to the immersion heater in the tube. In this way, ice can form on the surface of the water in the tank, but the water inside the aluminum tube is kept free from freezing, and by radiation, a sufficient area around the tube so that, regardless of low temperature, the true level of tank water is monitored at all times — regardless of how thick the ice formation might become. *Magnetrol.*

Circle number (50) on reply card.

POWELL LUBRICATED PLUG VALVES

performance that makes a world of difference

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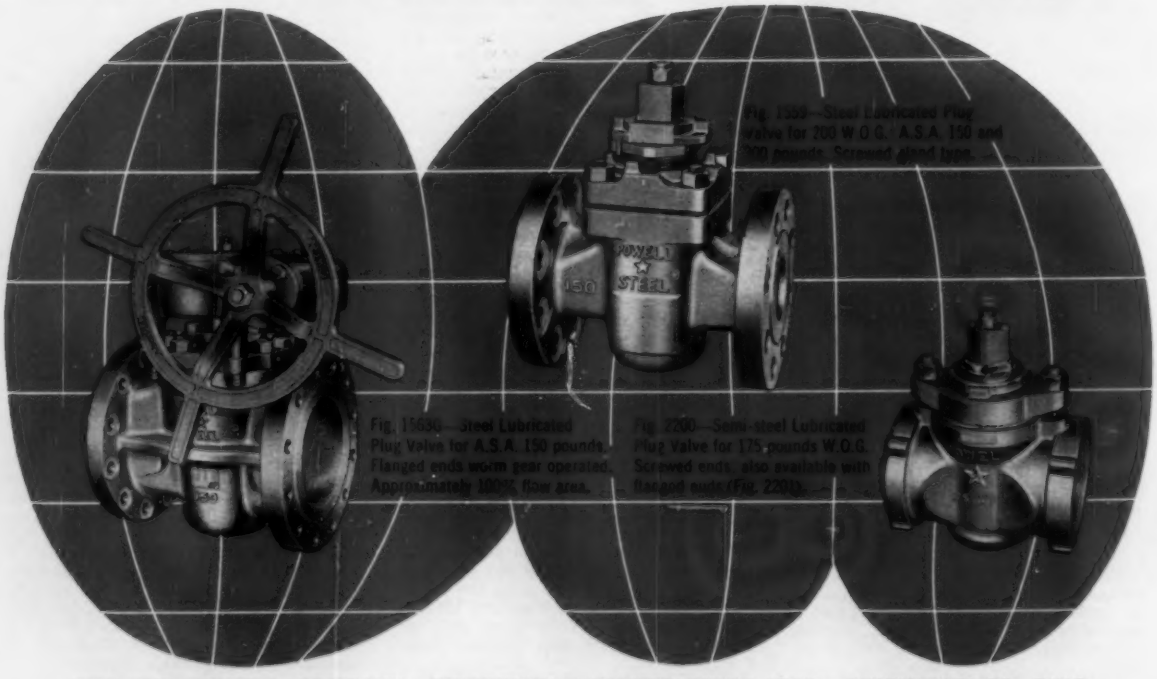

Fig. 15630—Steel Lubricated Plug Valve for A.S.A. 150 pounds. Flanged ends worm gear operated. Approximately 100% flow area.

Fig. 2200—Semi-steel Lubricated Plug Valve for 175 pounds W.O.G. Screwed ends, also available with flanged ends (Fig. 2200).

THE WM. POWELL COMPANY • DEPENDABLE VALVES SINCE 1846 • CINCINNATI 22, OHIO

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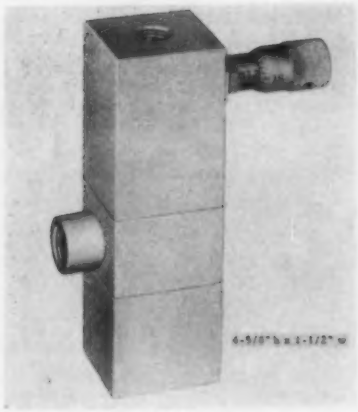

Volume Regulator

Constant volume regulator is designed to provide fully automatic regulation for control applications where constant volume output of gas or air is necessary regardless of fluctuating pressure drop. Capacity is controlled by micrometer adjustment to assure accuracy of desired output. This output volume is from 5.0 to 180 std cu ft per hr at pressure differentials from 1 to 25 psi. *George W. Dahl Company, Inc.*

Circle number (51) on reply card.

Mechanical Dust Collectors

New and improved involute design of mechanical dust collector permits high efficiency collection of abrasive or heavy dust loadings. Any size job can be handled through wide variety of arrangements. Catalyst dust suspended in reactor effluent and regenerator flue gases may be efficiently collected by involute-type collectors. With 24 in. Cyclo-trell collector containing steel mesh liner, and an electrostatic precipitator, the combined units remove even finest residual catalyst particles. To handle highly abrasive dusts, collectors can be fitted with steel mesh liners incorporated with castable cements. Larger diameter tubes and new hopper discharge valve are included in recent design improvements. *Research-Cottrell, Inc.*

Circle number (52) on reply card.

Turbine Agitator

Wide flexibility in meeting thousands of requirements from standard Moduflex components is only one advantage. Through modern techniques of machine design each precision machined module fits with others to form quiet, efficient and low headroom turbine agitator. Units are designed, manufactured and rated in accord with AGMA standards. Moduflex drives are inventoried in 7 case sizes, each containing one of 17 selected ratios of bevel and helical gears in either 2 or 3 stages. Positive pump lubrication protects all moving parts. Agitators are thoroughly engineered for heavy-duty continuous use with minimum maintenance. *Chemineer, Inc.*

Circle number (53) on reply card.

Solenoid Regulators

Solenoid actuated regulators for on-off control are now available for use wherever remote shut-off, remote start-up, automatic safety shut-off and combination pressure and temperature control with electric signal are needed. When solenoid opens, it allows steam to enter pilot chamber and operate main valve as normal pressure regulator. When solenoid closes, steam supply to pilot is shut off and main valve closes automatically. Available in ductile iron ½-3 in., bronze ½-2 in., and cast iron 2½-3 in., regulators are suitable for maximum temperatures of 500 F and pressures of 250 psi. ½-2 in. No. 1163 Series has screwed ends and 2½-3 in. No. 1163-F Series has flanged ends. Units feature packless construction, silent operation, freedom from wire drawing and positive shut-off. *Jordan Corporation, Division of OPW Corp.*

Circle number (54) on reply card.

High-Speed Magnetic Tape

A new high-speed magnetic tape transport that is expected to greatly increase

the life expectancy of magnetic tapes used with electronic data-processing systems has been announced. *Minneapolis-Honeywell Regulator Co.*

Circle number (55) on reply card.

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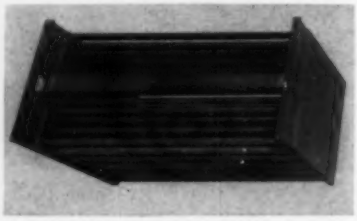
Modular Entrainment Separators of karbate impervious graphite for effective separation of entrained liquids from corrosive gas streams are now available. De-



signed for high collection efficiency and low pressure drop, the corrosion-resistant modules measure 1 by 2 ft and can be easily assembled into banks to fit any duct or process vessel.

Type MV entrainment separator modules are of unitized construction, and operate on the principle of impingement plus venturi action. *National Carbon Co.*

Circle number (56) on reply card.

4-Way A-C Solenoid Valves

A new line of 4-way a-c solenoid valves, featuring several unique characteristics, has been announced. Interesting new design approaches — both mechanical and electrical — provide these new solenoid valves with a combination of high fluid capacity, high pressure ratings, light weight, and low current consumption. *Waterman Hydraulics Corp.*

Circle number (57) on reply card.

Automatic Flash Tester

New device automatically performs the Cleveland Open Cup Flash Test reducing by one-third the working time required to perform a common test used in refineries and laboratories to assure that lubricants meet quality specifications. Developed by the research department of *Mobil Oil Company*, the tester will be manufactured by *Precision Scientific Company*.

Circle number (58) on reply card.

Hose Rack Extinguishers

200 and 400 lb pressurized dry chemical hose rack extinguishers are approved for use on flammable liquid, gas and electrical fires, and can be either wall, floor or truck mounted. Units feature simple self-evident actuation and nozzle has off-on control lever. Nozzle discharges universal pattern delivering optimum fire extinguishing punch for range of 40 ft. Hose lengths of 50 or 100 ft are available. When unit is pressurized with nitrogen or dry air to 450 psi, a force of 3 tons seals head, making it virtually leak and tamper proof. Extinguishers are supplied with dust and moisture proof gages. *Walter Kidde & Company, Inc.*

Circle number (59) on reply card.

Bronze Valves

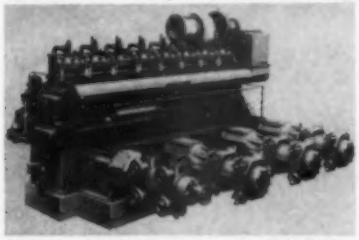
Two new lines of bronze valves, No. 229 C 200 lb bronze globe valve and No. 239 C 200 lb bronze lift check valve, have integral body seats with semi-crown face instead of screwed-in seats as in the Crane bronze valves they replace. No. 229 has a slip-on disc holder for fast and easy repair and ranges in size from ¼ - 2 in. Valves are regularly furnished with No. 4 discs for high pressure steam up to 450 F, and with No. 6 disc for cold water, air, gas, oil or gasoline service. *Crane Company.*

Circle number (60) on reply card.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Turbocharging Conversion Kits

The introduction of complete field turbocharging conversion kits designed for the majority of models in RA and HRA Gas-Engine-Driven Compressor Lines has been announced. Depending on model, size, shaft diameter and other design criteria, horsepower increases range



from 32 to 50 percent on the RA Series, and from 20 to 36 percent on the HRA Series. The new conversion packages provide a substantial reduction in fuel consumption per bhp and permit increased horsepower output, usually without the need for additional cooling service. Neither expanded buildings nor extra operating personnel are required for the extra horsepower. *Clark Bros. Co.*

Circle number (61) on reply card.

Magnetic Mechanical Seals

Effective magnetic-type mechanical seal has been developed which meets the need for simplicity of installation and small space requirements. Initial operational results of these seals with most fluids are good. While the seal is not offered as a cure-all in its present stage of development, it does meet a specific need in many applications and with further development offers promise for use in other services. *A. W. Chesterton Company.*

Circle number (62) on reply card.

Dip Pipes

Chemically inert dip pipes which will withstand severe agitation and thermal shock at temperatures to 500 F have been added to Resistoflex Corporation's line of Fluoroflex-T piping components made from Teflon. Pipes consist of a Schedule 40 steel housing completely lined and jacketed with Fluoroflex-T. Steel reinforcement provides necessary shock resistance required in excessively agitated reaction vessels. Gas and liquid tight seal betweeen the outer jacket and the extended inner liner is achieved by use of a Tantalum ring swaged over the end of the assembly. TS dip pipes are supplied complete with Fluoroflex-T packing gland and Fluoroflex-T jacketed nozzle flanges. Pipes are also manufactured with all-laminated and solid Teflon construction. Available with straight or 10 cents offset ASA flanges and ASA adapters in pipe sizes from 1 through 3 in. Larger sizes available upon request. *Resistoflex Corporation.*

Circle number (63) on reply card.

Epoxy Coating

A 100 percent solids epoxy coating can now be applied with conventional spray equipment because of newly developed EPON hardening agents, which provide controlled reactivity, require no heat to effect curing, are not adversely affected by high humidity and, when used with a liquid Epon resin base, do not present a fire hazard. Their use will provide usable pot life of several weeks compared with about one day when previously available curing agents are used. *Shell Chemical Corporation.*

Circle number (64) on reply card.

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DEVELOPMENT OF ADVANCED PROCESS CONTROL SYSTEMS

IBM's newly formed Advanced Systems Development Division offers assignments in the development of automatic computer control systems and application concepts.

A new division has been established by IBM to develop advanced concepts and techniques in the design and application of computer systems for new fields. This new division represents an interesting opportunity to work with newly developed technologies. The entire division is engineer-oriented; its sole purpose is to develop new systems and services to be marketed in several years by IBM. One area of immediate interest is the achievement of advanced systems and concepts for the automatic control of industrial processes of all types.

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PIPE JOINT CLAMP STOPS LEAKS
at joint where pipe is screwed into fitting

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PIPE JOINT CLAMP stops leaks at joints where pipe is screwed into fitting. Any temperature—any pressure up to 2,000 pounds. Saves the cost of tearing out and renewing leaky fittings. Prevents shutdowns. In stock at most oil supply stores.

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EMERGENCY PIPE CLAMPS for safe, sure, lasting repair of splits and rust holes in pipe. No pressure too high. Anyone can apply in a few moments. Made in all sizes, ½" to 12" for steel and C.I. pipe. Stocked by practically all oil supply stores.

Complete line of Repair Clamps. Send for Catalog 54!

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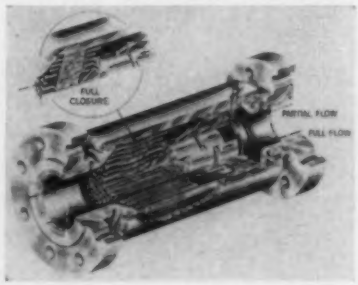
SOUTH BEND 21, INDIANA

New Equipment

Flexible Silent Valve

Flexible silent valve raises efficiency of most fluid systems. Aeration, cavitation, surging, vibration and the resultant noise, all undesirable physical phenomena associated with the rapid flow of fluids, are



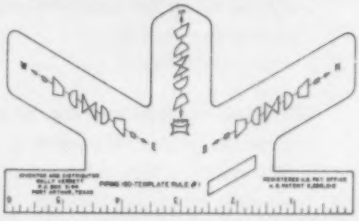
now virtually eliminated by new Silent Valve. This artist's cutaway drawing shows the valve in three operating positions — fully closed, partially open and wide open. Regulation of the valve is accomplished by means of a hydraulically actuated piston. The piston, acting against a perforated metal ram plate, compresses a molded elastomer insert having a matching hole pattern. As the insert is compressed, the flow passages are reduced in diameter and throttling is effected. At full compression, these channels are closed and the fluid flow completely shut off. *Aerojet-General Corp.*

Circle number (65) on reply card.

Isometric Piping Drawing Instrument

A new template designed for isometric pipe drawings has been patented by a graduate engineer. This simple tool enables a standardized isometric drawing to be made of all pipe layout sketches.

Because of its simplicity, even beginners can make professional drawings the first time. Other features include: Pocket



size cut-outs for most common fitting symbols, laminated clear heavy-grade plastic, rounded corners for uniform angles, and handy compass orientation points. Engineers, operators, pipe sketchers, detailers, and designers would find this a very useful tool for their drawing boards. *Wally Verrett.*

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Makes Tough Jobs Easy

A new solvent additive, designed specifically for the removal of stubborn compounded soils which resist standard acidic or alkaline detergent solutions, has just been introduced by Oakite.

Oakite Acalaid is economical because it is used only where needed to boost standard solutions. Field tests have demonstrated its usefulness in cleaning heat exchangers and processing columns. The new material is neutral in pH, assuming the pH of the solution to which it is added. *Oakite Products, Inc.*

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Dann Goodson, *Manager Motor-Driven Compressor Sales, The Cooper-Bessemer Corporation, explains...*

How Cooper-Bessemer's new, compact Air Compressors simplify installation and reduce costs

The DMR compressors shown here are two models of a new line of *compact, 720 rpm* machines, unmatched in reliability. With these units, Cooper-Bessemer introduces a new standard of installation economy. So highly compact, the DMR compressors are readily installed in existing space, avoiding the need for additional housing facilities. They can be located at strategic points throughout the plant to supplement existing air line services without additional feeders to help supply your production needs at minimum cost.

The new DMR units come completely equipped with integral motor-drive and intercooler... ready for operation. Their control can also be integrally mounted as shown. They are available for two-stage applications in the range of 500 to 2000 cfm and discharge pressures of 80 to 125 psi... also for single-stage and three-stage operation.

The introduction of this new line of air compressors, plus the portable tool facilities of our new subsidiary, The Rotor Tool Company, enable Cooper-Bessemer to give you full-scope service for your industrial air power needs. Call the nearby Cooper-Bessemer office or air compressor agent for Bulletin No. 94 on the new DMR line.

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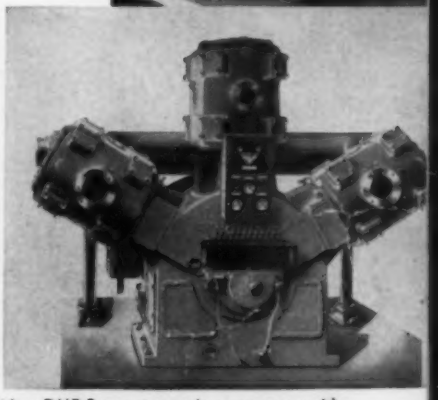

New DMR-3 two-stage air compressor with integral control. Ratings of 300-350 hp.

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DMR-2 TWO-STAGE
AIR COMPRESSOR
WITH
EN-TRONIC CONTRO
100 TO 250 HP

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REDUCED PROCESSING and RETENTION TIME!

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New Literature

Bed Demineralizers . . . A 4-page bulletin on a new line of standardized "Uni-Pac" packaged mixed bed demineralizers, designed specially for process water applications. *Cochrane Corporation.*
Circle number (68) on reply card.

Belt Drum Filter . . . A new 12-page bulletin describing how 5-way savings can be made in the continuous vacuum filtration of difficult slurries with the use of the Eimcobelt continuous belt drum filter. *The Eimco Corp.*
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Boiler Water Gages . . . New Data Unit No. 360 gives features and technical data on new Jerguson Refracolor Gages. These gages are for high pressure installations and show the water level as green, while the steam area is red. *Jerguson Gage & Valve Co.*
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Building Trades Pumps . . . Complete product descriptions, dimensions, application data and performance characteristics of an augmented line of building trades pumps are included in a new 12-page bulletin. *Food Mach. & Chemical Corp.*
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Circuit Breakers . . . The electrical industry's most complete and diversified line of molded case circuit breakers is described in a comprehensive new bulletin. The illustrated, 40-page, 2-color bulletin gives ratings, specifications and operating characteristics as a guide to designers, contractors and consulting engineers in selecting breakers for a wide variety of applications. *I-T-E Circuit Breaker Co.*
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Cast Aluminum Coupling . . . A new type of cast-aluminum coupling, for joining extruded aluminum stream-traced piping, is described in bulletin PF-1. Drawings illustrate 3 basic types of couplings. *Alcast Fittings.*
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Constant-Voltage Chargers . . . Technical data sheets and bulletin helpful in selecting and using specific models of Exide constant-voltage, silicon-rectifier (UR) chargers for stationary-type batteries. *The Elec. Storage Battery Co.*
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Corrosive Service . . . Information and engineering data on a new corrosive service shaft seal. The seal described is designed to handle all concentrations of acids and salts, strong oxidixing or reducing agents and all organic compounds. *Crane Packing Co.*
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Corrosive Solutions . . . A 12-page illustrated bulletin on Karbate impervious graphite immersion heat exchangers and circulating steam jets for heating or cooling corrosive solutions in all types of tanks. *National Carbon Co.*
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Instrumentation Data Sheet . . . A 2-page data sheet which describes Speedomax H indicators, recorders and controllers for pH and redox. Outlined are specifications of instruments, including a chart which lists types of control action. *Leeds & Northrup Co.*
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Explosion-Proof Controls . . . A 2-color, 4-page booklet on explosion-proof controls, indicating, non-indicating and recording. *Partlow Corp.*
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Flow Meter . . . A new, low-cost, high capacity flow meter featuring an integral by-pass design is described in Design Specification Sheet No. D-132. *Brooks Rotameter Co.*
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Gas Chromatographic Analysis . . . Instrumentation Data Sheet describes how the F & M Model 202 Gas Chromatograph, employing an Electronik recorder, has increased the speed, scope and accuracy of gas chromatographic analysis. *Minneapolis-Honeywell Regulator Co.*
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Industrial Controls . . . Directed toward the design and process engineer, the 23-page, 2-color, booklet "Industrial Temperature Measurement and Control" notes that engineers have found that they can save money by eliminating guesswork in temperature indication and control. *The Partlow Corp.*
Circle number (33) on reply card.

Industrial Linings . . . 3-page, 3-color, bulletin "Industrial Linings in Hexmetal," gives information on Hexmetal that provides 'Bone' structure in any form of plastic lining and method of attaching it to steel walls. *Causeway Reinforcement, Ltd.*
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Industrial Waste . . . A new industry bulletin entitled "Instrumentation for Treatment of Industrial Wastes" is a compilation of article reprints, and offers some case histories of how instruments are applied to industrial waste treatment systems to prevent stream pollution. *Minneapolis-Honeywell Regulator Co.*
Circle number (35) on reply card.

Instruments for Control . . . A 1960 catalog describing and illustrating instruments for electronic, biological and chemical measurement and control. *Keithley Instruments, Inc.*
Circle number (36) on reply card.

New Laboratory Items . . . 38th in the series, "What's New for the Laboratory" is the newest publication featuring new laboratory items. *Scientific Glass Apparatus Co., Inc.*
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Organic Chemicals . . . A new 28-page physical properties booklet, describing more than 400 synthetic organic chemicals, with information on applications, physical properties, and shipping data. *Union Carbide Chemicals Co.*
Circle number (38) on reply card.

Pipe, Valves and Fittings . . . New 36-page handbook for engineers which contains pertinent and detailed information on the use of plastic pipe, fittings and valves, including specification, design, and installation information as well as a comprehensive corrosion resistance comparison chart for 7 types of plastic pipe carrying 162 chemicals. *Kraloy Plastic Pipe Co., Inc.*
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Sewage Plant Effluent . . . This 16-page study reports on how sewage plant effluent can be used satisfactorily in recirculating cooling systems and as boiler make-up provided it is adequately treated to avoid operating problems such as organic growths, deposits and corrosion in cooling systems and foaming, carryover and ammonia corrosion in boiler and steam systems. *Betz Laboratories, Inc.*
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New Literature

Polystyrene Insulating Material . . . An 8-page circular which discusses a brand of expanded polystyrene insulating material, its physical properties, standard dimensions, and recommends thicknesses for a wide range of temperature conditions, with photos and drawings. *United Cork Companies.*
Circle number (111) on reply card.

Process Industries . . . Catalog guide of equipment for the process industries, with descriptions included of compressors, vacuum, centrifugal, axial flow and turbine pumps, and valves for fluid flow; and liquid heaters for heat transfer. *Allis-Chalmers Manufacturing Co.*
Circle number (112) on reply card.

Pump Performance . . . New 4-page, 2-color bulletin describing complete line of seal-less pumps for leak-proof pumping, covering design, operation, and selection of proper "canned" pump. *Fostoria Corp.*
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Servo Systems . . . A bulletin that highlights a few of the advantages of applying the "Building Block" principle to velocity or positional control servo systems; also data file folder designed to keep in one package the servo system information. *Vickers, Inc.*
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Solenoid Valve Stock List . . . New colorful 16-page solenoid valve stock list and selection guide, containing engineering information, selection guide, illustrations and flow diagrams. *Automatic Switch Co.*
Circle number (115) on reply card.

Steam Traps and Drainage . . . New, informative booklet on steam traps and condensate drainage, giving fundamental facts on condensate drainage and all types of steam traps. *Barnes & Jones, Inc.*
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Surfactants . . . 44-page booklet, describing the properties and uses of Tergitol surfactants, containing extensive data for 8 nonionic and 4 anionic Tergitol surfactants, including selection, solubilities, properties, formulations, applications, performances, specifications and test methods, shipping, bulk storage, and physiological properties, a detailed bibliography and reference section. *Union Carbide Chemicals Co.*
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Test Set Calibration . . . New catalog illustrating and describing a test set in detail which permits the accurate and easy calibration of all types of Optical Pyrometers. *Pyrometer Instrument Co., Inc.*
Circle number (118) on reply card.

Tube Dimension Standards . . . Two new tube dimension standards, API Standard 630 establishes standard sizes and lengths of heater tubes recommended for all refinery services, and API Standard 640 contains recommended size, thickness, and length of ferrous and non-ferrous tubes most commonly used in conventional shell and tube refinery heat exchangers — price 50 cents a copy. *American Petroleum Institute.*
Circle number (119) on reply card.

Tubing and Pipe . . . New Bulletin on tubing and pipe which outlines applications of super corrosion resistant alloys and describes their resistance to corrosive fluids, with tables showing comparative resistance, chemical analysis and physical and mechanical properties as well as size ranges and tolerances of pipe and tubing. *Carpenter Steel Co.*
Circle number (120) on reply card.

You get DUAL SEATING with Pacific's BTV-BTR Gate Valves

Pacific's dual seal BTV/BTR gate valves incorporate the effective application of BOTH metal-to-metal seal and mechanically locked-in elastomer secondary seal to effect a positive shut off in a gate valve designed to meet all petroleum and chemical service applications. For the first time, a valve manufacturer is able to utilize two elastomer-type materials, Viton* and compounded rubber, which supplement each other, to offer effective sealing over an unusually wide temperature range and resistance to a great many more corrosive materials and combination of fluids. With the unique dual seat design, seat efficiency is increased as line pressure is increased. Valve seal is not affected by change in direction of flow, by pressure differentials or by line fluctuations. Important new safety feature permits visual proof of positive seat tightness after each valve closure. This test procedure is quick, certain, and safe! Available in carbon and alloy steels. 150 lb. pressure series 1½" to 24", 300 lb. pressure series 1½" to 16". Temperature limitation −20°F. to +400°F. For additional information ask for Brochure BV-1.

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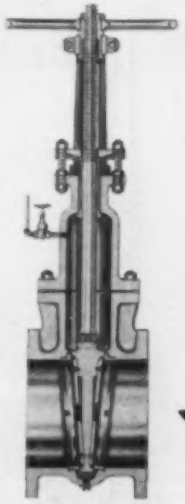

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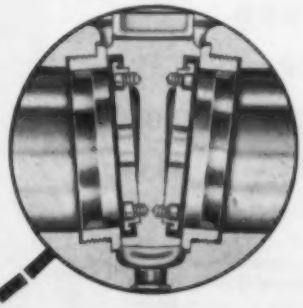

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Sales offices in most principle cities.

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REFINING PERSONALS

▸ Appointment of **M. F. Wirges** as chief engineer, effective January 1 has been announced by J. E. Heston, president of Arkansas Fuel Oil Corporation, succeeding **L. F. Babcock** who is retiring. Wirges holds BS and MS degrees in chemical engineering from the University of Oklahoma. A member of the American Institute of Chemical Engineers, API, Chamber of Commerce, and on the board of directors of the Natural Gasoline Association of America, Wirges also served as chairman of the Oklahoma Section of AIChE, as a member of the Technical Committee for NGAA, and was Chairman of the Program Committee for the NGAA meeting in Dallas April 1959.

▸ **W. I. Leitzell** and **Rex W. Smyth** have joined the Technical Development Section of the Petrochemicals Department, Gulf Oil Corporation. They will assist in planning and developing new projects for Gulf's expanding petrochemical activities.

▸ **Homer Z. Martin,** author of numerous technical articles and 74 patents, has been appointed coordinator of petroleum process research at Esso Research and Engineering Company. Since joining Esso in 1937 his main research has been on Esso Research-developed refining process known as fluid catalytic cracking. He has also done research on synthetic fuels and other process developments.

Until his new appointment, he was special assistant in the office of the coordinator of fuels processes and was previously director of the process research division.

▸ **T. G. Hughes,** president of California Chemical International, Inc. and Oronite Chemical Company, (subsidiaries of Standard Oil Company of Calif.) has named **Louis Oleari** as assistant manager, Latin America-Asia division. The Latin America-Asia territory includes Japan, Hong Kong, Australia, Thailand, India and other Far East markets as well as Mexico, Central and South America and the Caribbean countries.

▸ Stone & Webster Engineering Corporation has announced the election of **T. Cortlandt Williams** (president since 1955) as chairman of the board, and **Fred W. Argue** (executive vice president) was elected president, effective January 1, succeeding Mr. Williams. (During the past 26 years, Mr. Williams has directed the construction of many different projects, including the atomic energy installations at Oak Ridge, Tennessee.)

T. C. Williams

F. W. Argue

A. L. Hartridge

Dr. A. J. Good

Other management changes, effective January 1, include the election of **Alfred L. Hartridge** as executive vice president, and of **Dr. Arthur J. Good** as vice president and treasurer.

F. C. Westphal Jr.

▸ **Frederick C. Westphal, Jr.** has been named manager of Esso Standard Oil Company's Bayonne (New Jersey) refinery, succeeding **David F. Edwards,** who joined Humble Oil & Refining Company as employee relations manager. Westphal was formerly administrative superintendent of Esso's Bayway refinery in Linden, N. J.

▸ **William H. Burke** has joined the manufacturing department at Monsanto Chemical Company's Plastics Division plant at Texas City, Texas, after serving with Thiokol Chemical Corporation at Marshall, Texas.

▸ The Dow Chemical Company has announced the election of **Macauley Whiting,** general manager of the company's Midland division, to the board of directors; and, **Roe E. Withrow, Jr.,** has been appointed assistant to the president of Dow Chemical International Ltd., S.A., a Dow subsidiary.

▸ **Clifford R. Crusan** has been appointed president and general manager of Turbocraft, Inc., **Harry E. Morgan,** chairman of the board of directors, announced.

C. R. Crusan

E. D. Loughney

▸ **Leslie D. Burritt** has been appointed director of the construction engineering division of Esso Research and Engineering Company. Formerly associate director of the division he succeeded **Allen J. Ely** who retired after more than 40 years of service.

▸ The board of directors of The British American Oil Company has elected **Edward D. Loughney** as president and chief executive officer, succeeding **E. D. Brockett** (who has been named executive vice president of Gulf Oil Corporation.)

DETERMINE Moisture CONTENT of JET FUELS OILS GASES with the MODEL W ELECTROLYTIC MOISTURE ANALYZER

Full scale on most sensitive range,

to one milligram of water per liter of liquid. To 10 p.p.m. of moisture by volume in gases.

Direct reading scales— no computation necessary.

Includes novel self checking features.

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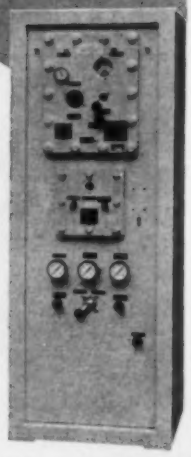

Explosionproof Universal Model W. (Other models including portable models for moisture in gas are available.)

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Second Annual Pipeline Handbook Issue

ALLIED CHEMICAL'S* HOTLINE ENAMEL SOLVES HOT-SIDE PROBLEMS

Allied Chemical's Hotline Enamel takes high temperature punishment from the hot-side of compressor stations . . . for years! Allied Chemical's Hotline Enamel won't crack at −10°F.—as proved in laboratory tests and on-the-job performance for leading public utility companies.

Allied Chemical's *Job-Matched* Hotline Enamel is derived from coal-tar pitch, thus possessing inherent protective properties against the damaging effects of water, soil chemicals and electrical currents. In addition to these properties, Hotline Enamel is bargain rated both for initial cost and long-run service.

Provides improved protection under all these specific conditions:

1. Hot gas pipelines, on discharge side of compressor stations where line temperature is above 120°F.
2. On pipe-type cables or "oil-o-static lines" which are subject to internal electrical heat from high-voltage surges.
3. Warm, swampy areas or other places where excessive soil stress on pipelines is encountered.
4. Areas where backfill and trenches are rough, rocky or contain foreign objects which normally penetrate softer coatings.
5. Pipelines (such as heated fuel lines) where temperatures are consistently high most of the time. but do not exceed 180°F. or for short-term exposure, 200°F.

*Though we've changed the name from Barrett Protective Coatings to Allied Chemical, you receive the same famous protection — pipeline coatings proved and improved for three generations.

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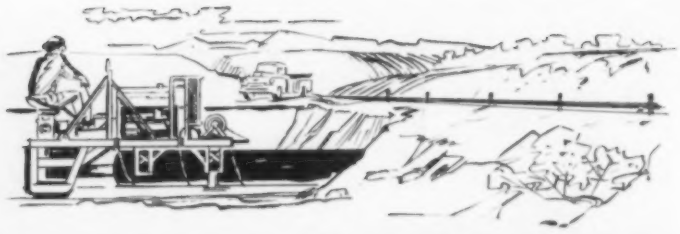
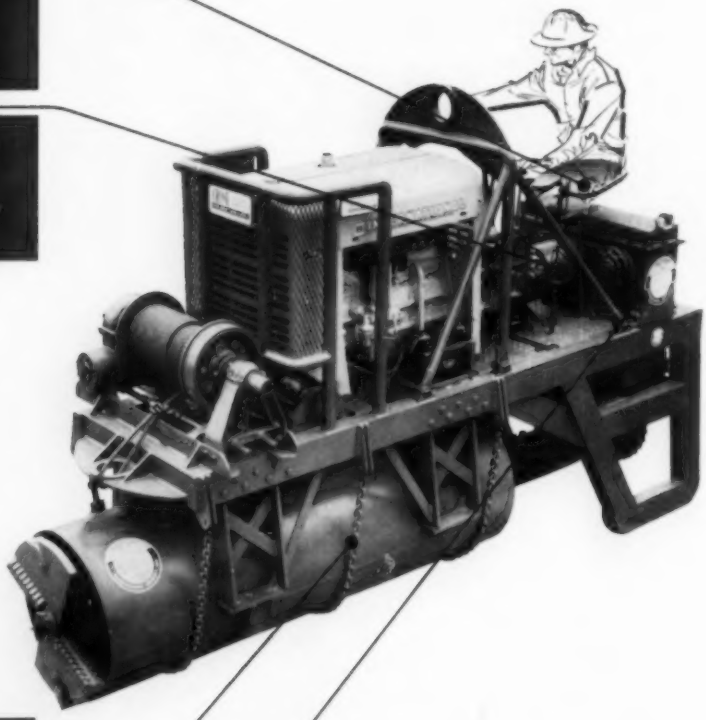


NEW ROAD BORING MACHINE

FIELD-TESTED
TOP PERFORMANCE



The new Crose Road Boring Machine provides the fastest, simplest, most economical way for boring crossings and installing casings up to and including 42" in diameter. Heavy duty torque converter and reverse-o-matic transmission deliver full, constant speed and smooth power flow . . . let you switch auger from forward to reverse without engine slowdown . . . no gear shifting.

The smaller Model RBA Crose Road Boring Machine is still available for casing up to 24".

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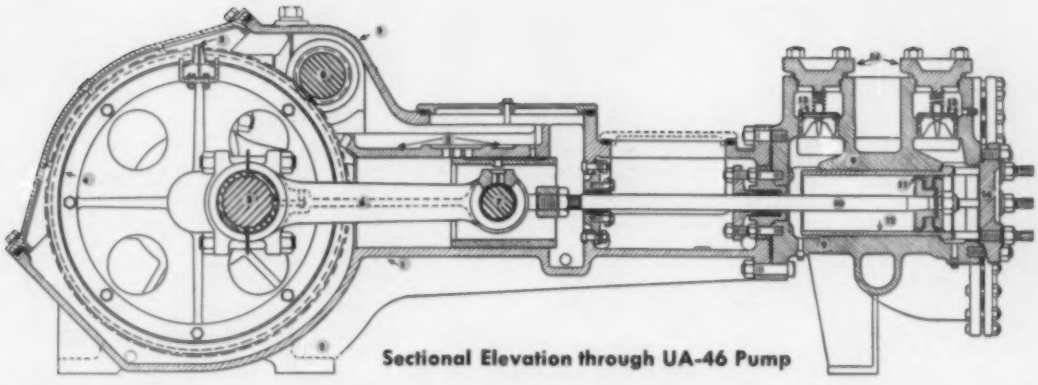
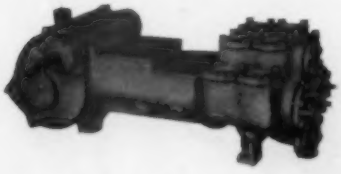
Ever look inside a

Bethlehem Duplex Power Pump?



Sectional Elevation through UA-46 Pump

1) Frame—one piece alloy-iron casting, rib-reinforced
2) Oil Chest—"heart" of the controlled-gravity-flow lubrication system
3) Oil Scraper—collects lubricant from gear rim to supply oil to all parts of power end
4) Main Gear—removable continuous-tooth herringbone
5) Crank Shaft—steel casting, normalized and tempered
6) Connecting Rod—normalized and tempered steel; H-section design
7) Crosshead Pin—alloy steel, hardened and ground
8) Pinion Shaft—heat-treated forged steel with integral pinion gear
9) Fluid-End Casting—moly-iron, steel, or aluminum-bronze
10) Piston Rods—steel, stainless steel, or aluminum-bronze; API taper or straight shank
11) Pistons—chrome-iron snap-ring, composition-cup, or slush type
12) Liners—interchangeable; alloy cast iron, hardened aluminum-bronze, or special order materials
13) Valves and Seats—hardened steel, aluminum-bronze, slush-type, or Nylon disc; interchangeable
14) Valve Covers and Cylinder Heads—moly-iron, steel, or aluminum-bronze



Inside and out, the durability of our U-series pumps is plainly evident. Solidly built for continuous operation at full load, these heavy-duty pumps are designed to give long and economical service in many kinds of applications:

- Waterflooding, disposal, and supply systems
- Mud transfer and general drilling service
- Crude oil pipeline and gathering
- Products, LPG, and oil-processing service

Ask our nearest office or store for complete details. Or write for descriptive literature.

There's a size for every job. Choose between the U-33, UA-46, and U-510

Capacities: 155 to 13,500 BPD
Piston-Rod Loads: 2,400 to 12,000 lb
Pressures: 340 to 1,698 psi

For higher pressures, investigate Bethlehem's Triplex pumps, the TP-3, TP-4, and TP-6

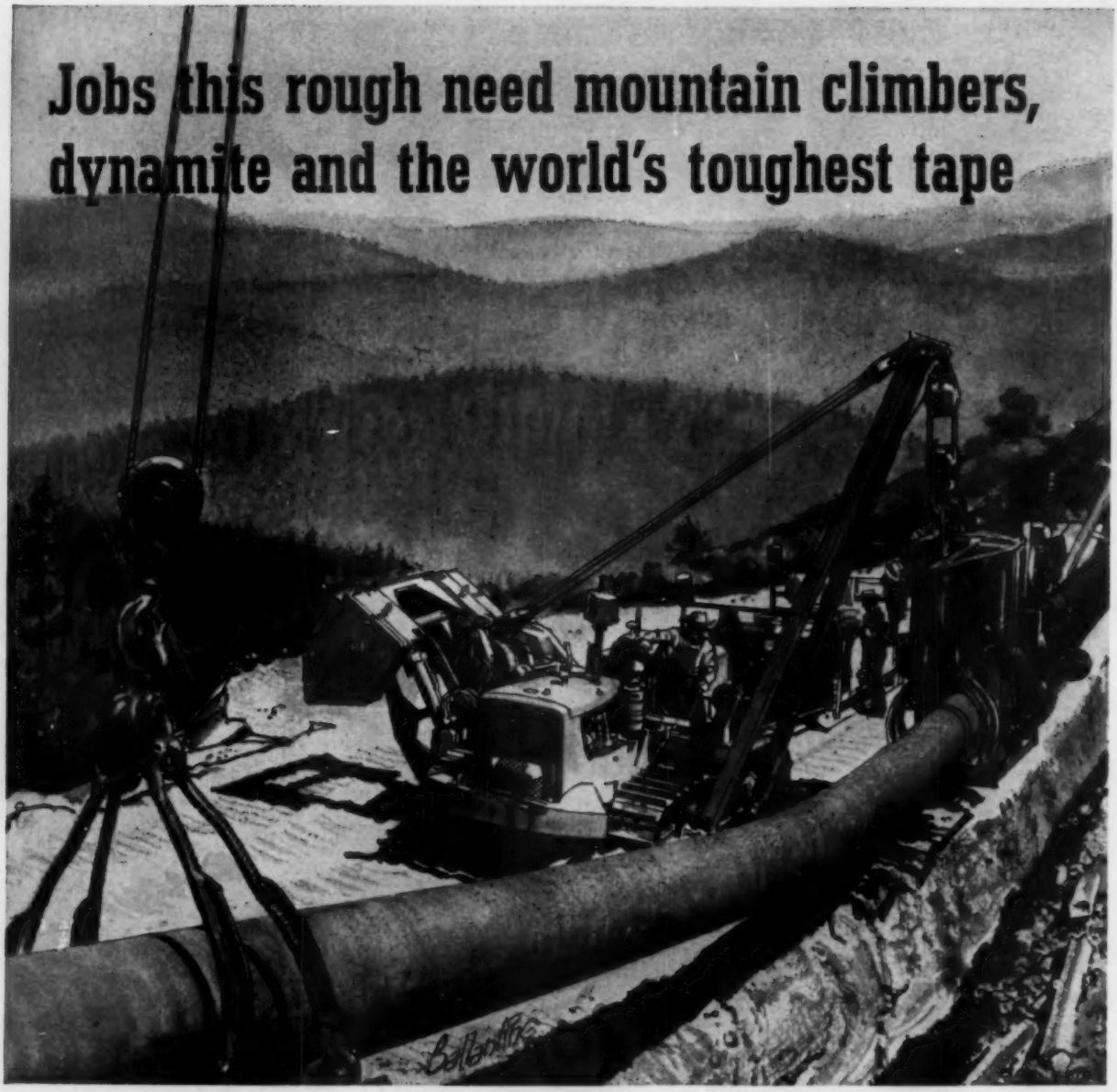
Capacities: 100 to 9,565 BPD
Plunger Loads: 3,580 to 10,000 lb
Pressures: 438 to 3,183 psi

BETHLEHEM STEEL COMPANY
SUPPLY DIVISION
General Offices and Export Dept.: 21 E. Second St., Tulsa, Okla.
Canadian Distributor: Bethlehem Supply Company of Canada, Ltd., Calgary, Alberta, Canada

BETHLEHEM STEEL · **SUPPLY DIVISION**

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Jobs this rough need mountain climbers, dynamite and the world's toughest tape



New Mandalay line goes through solid rock, up 40% grades, over 8,000-ft. mountains—with Polyken protection all the way

Before they took on 50 grueling miles of treacherous southern California mountains, the Richfield Oil Company people gave their materials a pretty thorough going over. Among other things, they made doubly certain of their protective coating.

Most Practical Protection Yet

They used Polyken's latest development, Extra Strength No. 960 Pipeline Roll. Like a lot of other large companies in recent years, they discovered that Polyken is the toughest, most practical protection you could ask for in modern pipe coating.

Many Hundreds of Miles of Proof

Who are these other companies? There's the Houston Texas Gas and Oil Corporation. They put Polyken tape on 1600 miles of gas line from Louisiana to Florida. The National Iranian Oil Company used Polyken for 200 miles of desert and mountain line. Phillips Petroleum put Polyken on several hundred miles of line in Texas and Canada. Jagged rock, coral swamp,

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

burning sand and frozen ground—Polyken is at its best under the worst conditions.

The Question to Ask

When you start inquiring, be sure to ask these companies about relative costs. Compare Polyken with hot dope, and see for yourself how much they saved.

The Polyken method gets more footage *per day*, with far fewer men. With far less equipment and hauling costs. In fact, you have fewer problems all around—and enduring protection.

To get the complete details on savings and durability, check with your Polyken representative or call the Polyken Tape Coating Distributor nearest you. Or simply write Polyken, 309 West Jackson Blvd., Chicago 6, Ill.

Using tensioned-spindle equipment, pipe is cleaned and wrapped in one factory-smooth operation. Polyken Tape is ready. No primer, no drying or cooling. No fumes or fire hazards.

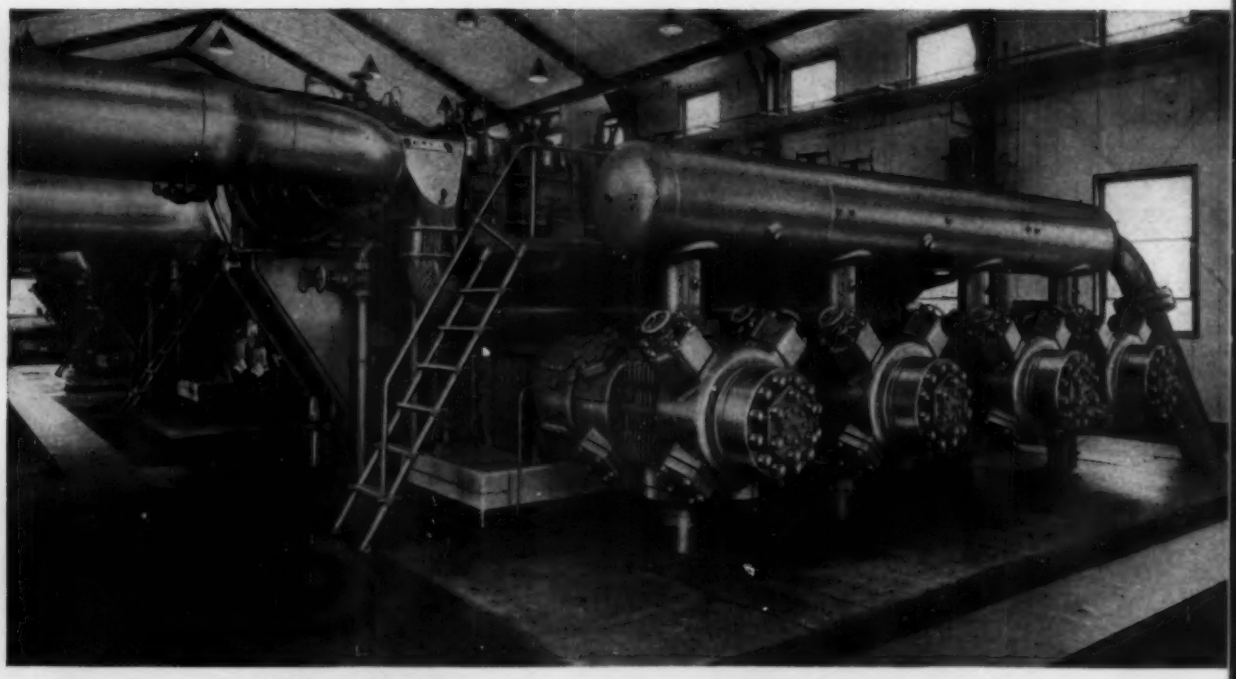
THE MODERN WAY

Polyken®

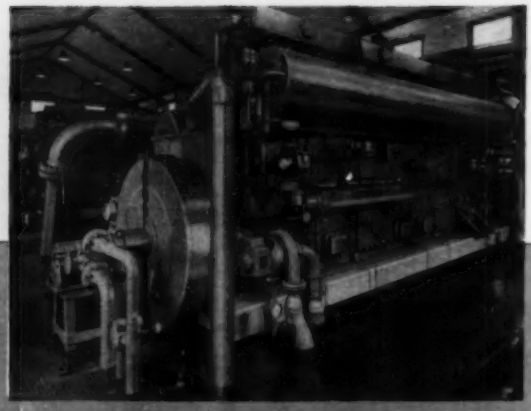
EXPERIENCED IN PROTECTIVE COATINGS

THE KENDALL COMPANY
Polyken Sales Division

PUSHBUTTON CONTROL



Three Clark 2050 bhp. HBA-8 turbocharged, gas-engine-driven compressors on stream in Texas Eastern's Linden, N. J., Station.



Notice how all functions are designed for automation. Hydraulic pump for radiator fan drive and water pump for jacket water are driven off of the compressor crankshaft.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

FROM 40 MILES AWAY

FOR ONE OF TEXAS EASTERN'S NEW COMPRESSOR STATIONS

At Linden, N. J., three 2050 bhp Clark turbocharged, gas-engine-driven compressors are under the complete supervision of an operator 40 miles away. From his control point upstream at Lambertville, the operator starts and stops the engines, adjusts speed, and keeps tabs on engine, compressor and pipeline functions which are displayed on the remote control panel.

Each of the Clark units at Linden may be controlled at from 60% to 110% of rated speed with constant torque loading. The pneumatically operated and remotely controlled compressor valve lifters and clearance pockets permit full utilization of the high flexibility inherent in these reciprocating compressors.

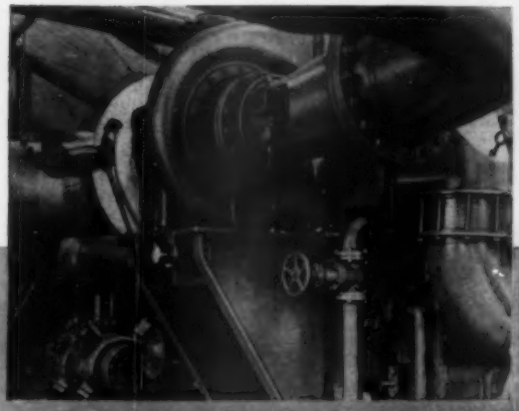
This is just one example of how Clark 2-cycle pipeline compressors are being used for automatic operations. As the trend toward more complete pipeline automation develops, look to Clark for the engineering know-how and the manufacturing experience to produce compressors that readily lend themselves to any degree of sequenced, automatic or remote control.

If you are considering pipeline expansion, it will pay you to learn more about Clark equipment and what it can do for you. Your inquiries are invited. Write:

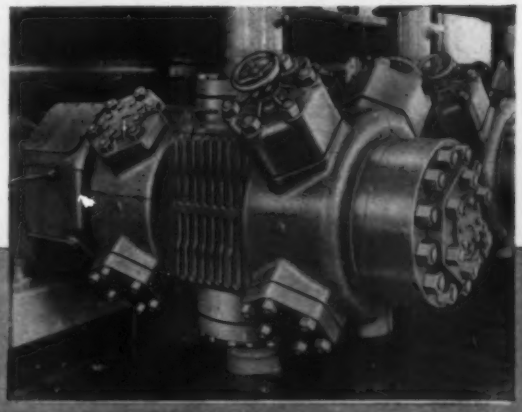
CLARK BROS. CO.
OLEAN, N. Y.

COMPRESSORS
GAS TURBINES

CLARK

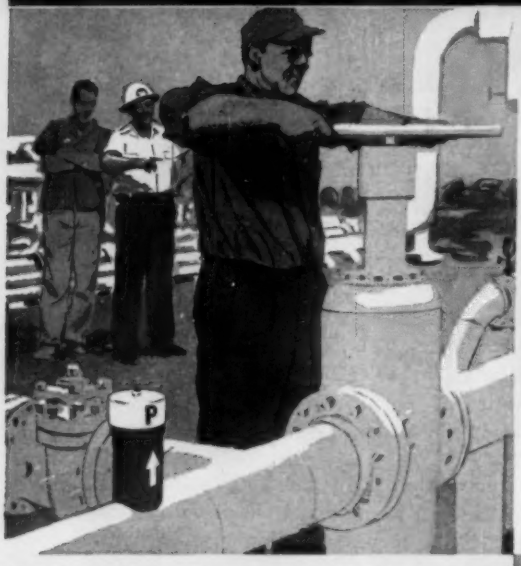


Clark Turbocharger and intercooler are mounted on the oil pump end of engines. Increased horsepower and improved fuel economy are direct results of turbocharging.



Clark Low Ratio Pipeline Compressor Cylinders are also designed for automation. Pneumatically operated valve lifters and clearance pockets are provided. Hand adjusted valve cap pockets provide additional capacity control.

NEWS FROM DOWN THE LINE!

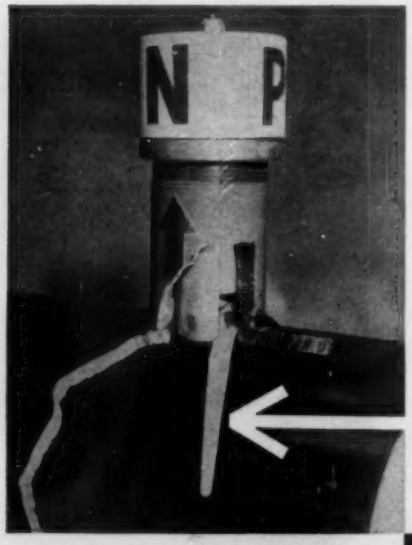


NEW WmSON "PIG-SIG II" CAN BE INSTALLED OR REMOVED UNDER PRESSURE!

❷ "The Pig-Sig II with the Electrical Indicator can signal arrival of pig to pump station operator or start operation of automatic equipment to open and close valves."

❶ "The station operator knows the pig has arrived because the Pig-Sig II visual indicator is in the "passed" position. He no longer needs to wait and listen at the scraper trap."

❹ "This completely new Pig-Sig II uses a standard 2" Thread-O-Ring Nipple. Easily installed under pressure with WmSon Tapping Machines, using a standard drill.
The Pig-Sig II is available with either an electrical or visual signal, extended or regular."



❸ "This new, improved long trigger action detects scrapers even in oversize pipe. Pig-Sig II is excellent for use in metering or calibration."

"Pig-Sig II" Patent applied for

• Write for Bulletin A-199

T.D. Williamson, Inc.

P. O. BOX 40 • TULSA 2, OKLAHOMA

REPRESENTATIVES AROUND THE WORLD

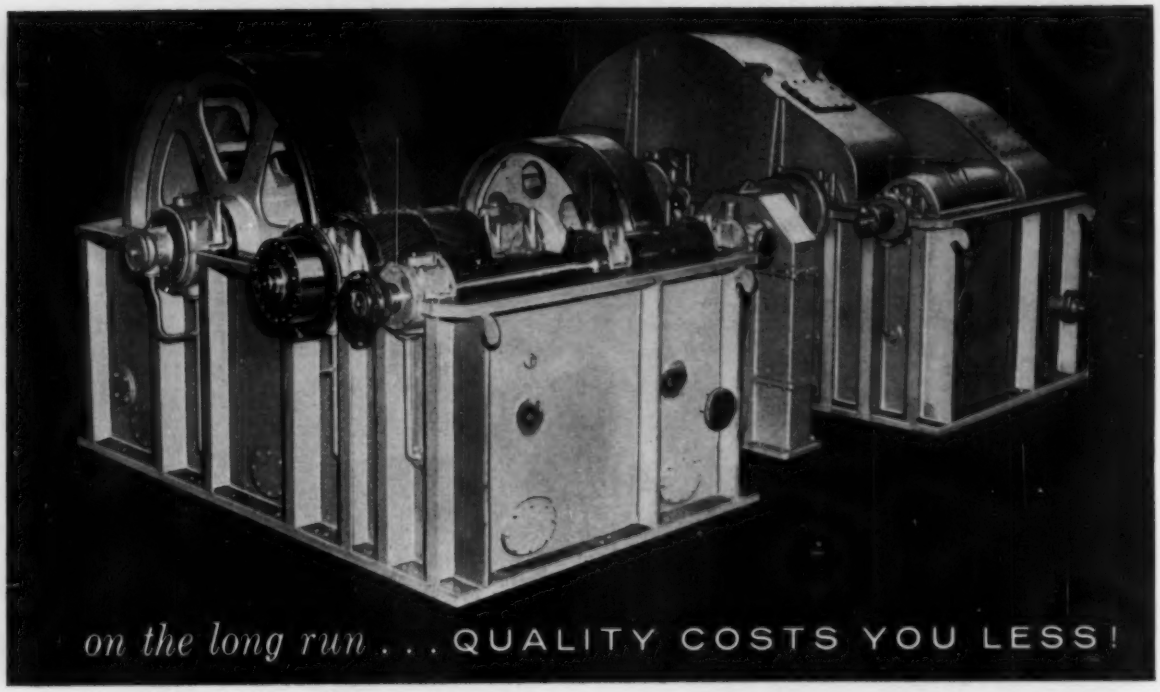
When the trench hits rock bring in the Insley **M's**

When the trench hits rock, hills or swamps, put Insley's proven pipeline performance to work for you. Bring in the Insley M's. The M's modern wide-vision cab houses pipeline features unmatched by any other machine on the market. Take advantage of the "pipeline experience" that's designed into every Insley. Get all the facts today. Ask your Insley dealer for catalog 300-3 or write Insley direct. Or better still, see an Insley M in action. We'll make the arrangements at no obligation to you.

This 22 miles of trenching for 30-inch line runs between Ottawa and Welda, Kansas. The contractor, Vaughn & Taylor, Odessa, Texas, is using three ¾ cu. yd. Insley M's.

THERE'S AN **INSLEY** WORKING NEAR YOU

INSLEY MANUFACTURING CORPORATION • GENERAL OFFICES • INDIANAPOLIS 6, INDIANA



WESTERN GEAR HIGH SPEED PIPELINE DRIVES CHOSEN FOR TRANSWESTERN PIPELINE FOR...

EFFICIENCY — Western Gear high precision manufacture guarantees low power losses through the gear drive ... a vitally important factor in the high proven efficiency of engine driven pipeline centrifugal compressors. Certified factory full-load, full-speed tests show a maximum of 2.0% loss through the 5,000 horsepower 2-stage drives pictured. Truly exceptional, considering the unit size and relatively high speeds encountered ... over 6,000 r.p.m. and 15,000 f.p.m. pitch line velocity.

DEPENDABILITY — Western Gear's unsurpassed application experience with 2-stage pipeline drives combined with years of close cooperation between Gulf-Interstate, Cooper-Bessemer and Western Gear engineers, assures dependability ... a Transwestern must. Rigid Western Gear quality control procedures include Magnafluxing, ultrasonic and X-ray inspection of vital parts, which afford maximum protection against sub-surface defects not discoverable by ordinary methods.

For full information on Western Gear pipeline drives, write, wire or phone: **INDUSTRIAL PRODUCTS DIVISION**
P.O. BOX 126 • BELMONT, CALIFORNIA • PHONE: LYtel 3-7611

WG INDUSTRIAL PRODUCTS DIVISION

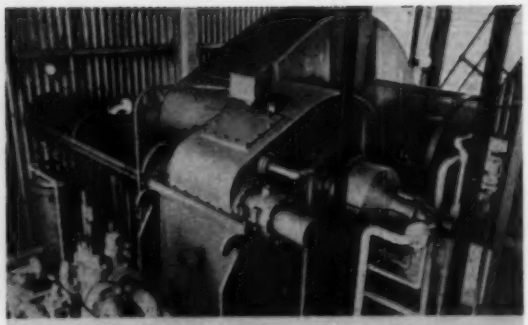
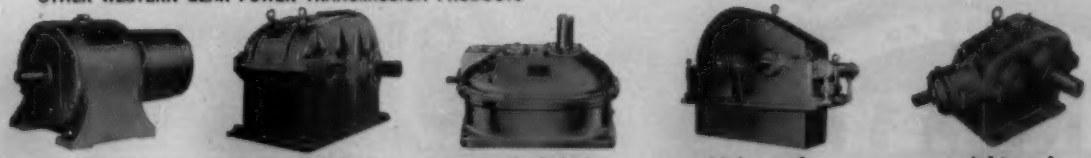


Photo above shows one of twenty units installed over three years ago on Columbia-Gulf Pipeline (formerly Gulf-Interstate Pipeline). Units are of the 2-stage type similar to the ten units currently being supplied for Transwestern. Cooper-Bessemer natural gas engines capable of delivering 5,000 horsepower at 360 r.p.m. drive through Western Gear Corporation Model 4525THS20-16 pipeline drives to Cooper-Bessemer centrifugal compressors at 6,050 r.p.m.

WG-6003

OTHER WESTERN GEAR POWER TRANSMISSION PRODUCTS



integral gearmotor | *parallel shaft reducer* | *vertical shaft reducer* | *high speed unit* | *right angle reducer*

AE·Lenkurt

HAS **EVERYTHING** YOU NEED FOR SYSTEM-WIDE COMMUNICATIONS

Microtel Microwave equipment, for instance—

Lenkurt *Microtel* provides maximum channel capacity per dollar, plus high-quality transmission . . . allows more protection against fading.

For instance, with Lenkurt 45BX Carrier, a single 6000-mc *Microtel* unit can accommodate from 4 to 264 voice channels. Channels may be dropped or inserted at any point.

Lenkurt *Microtel* has the additional advantage of being economical in operation. Power consumption is less than 300 watts. An advanced type of automatic frequency control dispenses with the need of crystal ovens or blowers. With the use of r-f circulators, 2, 3 or 4 *Microtel* terminals may be operated on a single antenna system.

Whether your expansion program calls for carrier, microwave, data transmission or supervisory control, AE-Lenkurt has the equipment, *plus* the engineering teams and talent, to handle the project from start to finish. And AE-Lenkurt services are tailor-made to your requirements.

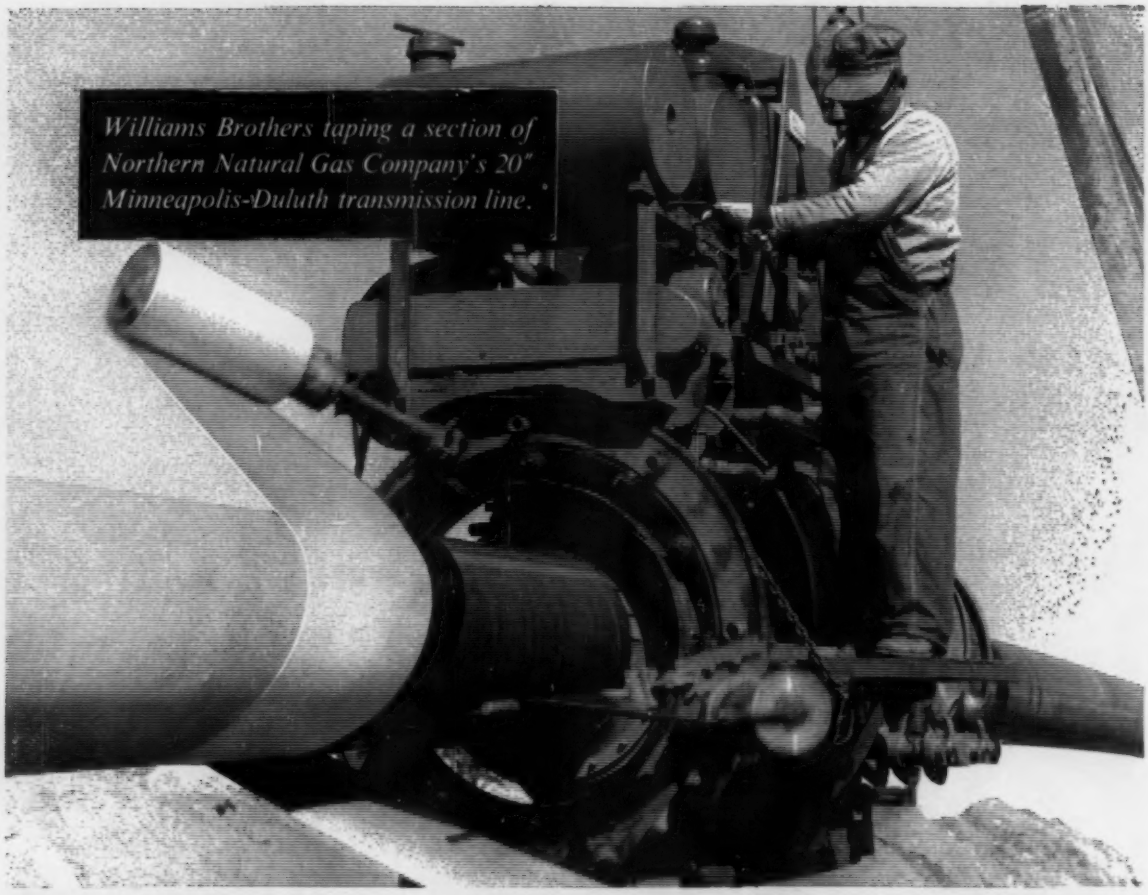
For more details on packaged planning and services, call your Automatic Electric representative, or write the Director, Petroleum Sales, Automatic Electric Sales Corporation, Northlake, Illinois.

AUTOMATIC ELECTRIC GENERAL TELEPHONE SYSTEM

Subsidiary of

GENERAL TELEPHONE & ELECTRONICS

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD



Williams Brothers taping a section of Northern Natural Gas Company's 20" Minneapolis-Duluth transmission line.

POLYETHYLENE TAPE by SEAMLESS

used for coating 53 miles of 20" main line in Northern Minnesota

AVAILABLE THROUGH THESE DISTRIBUTORS

ROYSTON LABORATORIES
Pittsburgh, Philadelphia, Atlanta, St. Petersburg

KENNETH PEISKER CO., Chicago

GULF SOUTHERN ENTERPRISES, Baton Rouge

NEE & McNULTY, INC., Tulsa, Houston, Denver

FROST ENGINEERING SERVICE CO.
Los Angeles, San Francisco

Here are the results...

- Actual construction time, 31 days.
- Reduction in construction costs.
- Less equipment required.
- Despite numerous swamps and peat bogs, the tape crew averaged approximately 9,000 feet per day.

Whether for main-line construction or an accessory application, Seamless has a specific tape for your installation. Write for field specifications and particulars.

SAFE-T-CLAD DIVISION

THE SEAMLESS RUBBER COMPANY

464 CONGRESS AVENUE, NEW HAVEN 3, CONN.

A SUBSIDIARY OF THE REXALL DRUG & CHEMICAL COMPANY

the **WALWORTH CUSTOMER**
wants a quick operating,
sure, tight valve. He chooses a

WALWORTH LUBRICATED PLUG VALVE

...and here's why

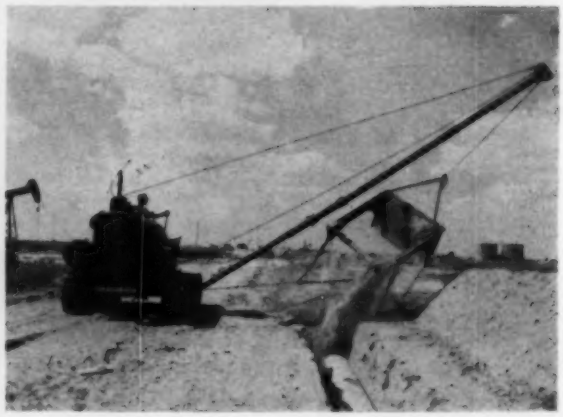
When the Walworth Customer has to decide on a valve that will close fast and easily, he wants to know HOW fast... HOW easily. Tight closure? Of course. But can the valve be serviced under pressure? Yes. Still, he tries one himself.

In the Walworth Lubricated Plug Valve he finds 100% tight closure because it is lubricant-sealed against leakage. He finds it opens or closes with a quarter turn. Then, and only then, he's ready to buy. If that's the way you like to buy valves, we want you, too, for a Walworth Customer. For details on all types and ratings of Walworth Lubricated Plug Valves, ask your Walworth Distributor.

Or write **WALWORTH** *750 Third Avenue, New York 17, N. Y.*

DISTRIBUTORS IN PRINCIPAL CENTERS THROUGHOUT THE WORLD

WALWORTH SUBSIDIARIES: ALLOY STEEL PRODUCTS CO. • CONOFLOW CORPORATION • GROVE VALVE AND REGULATOR CO. M&H VALVE & FITTINGS CO. • SOUTHWEST FABRICATING & WELDING CO., INC. • WALWORTH COMPANY OF CANADA, LTD.



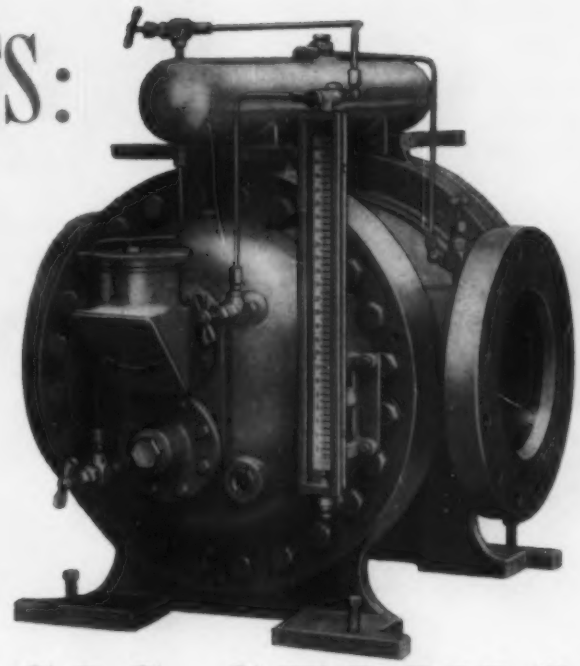
For digging and filling pipeline trench

Clevelands are <u>good</u> everywhere

The CLEVELAND TRENCHER Co. 20100 St. Clair Ave. • Cleveland 17, Ohio

R-C PRESENTS:

a new line of high-pressure rotary gas meters



FOR 600 PSIG SERVICE

A new line of 600 psig rotary positive displacement gas meters has been developed by Roots-Connersville to serve the needs of industries requiring extreme measurement accuracy in the higher pressure ranges. The meters are available in 4 sizes covering a range of from 84,000 to 1,600,000 scfh.

THIS NEW METER LINE IS IDEAL FOR MANY APPLICATIONS:

- City Gate Metering
- Transmission Line Metering
- Process Gas Metering
- Chemical Gas Manufacturing
- Gas Lifting
- Compressor Stations
- Well Head Measurements
- Steel Mills
- Underground Storage
- Metering of pulsating flow and surges, H2, 02, C02, NH3, LP gas, NO, He, C2H2, etc.

R-C rotary gas meters require an absolute minimum of maintenance . . . assure almost complete freedom from wear . . . exceptionally high accuracy in metering. A refinement of the basic R-C rotary-positive design which has proved its dependability over the years. These new meters for 600 psig service have incorporated simple in-the-line mounting, straight through flow . . . high-speed gears . . . and a welded steel outer case enclosing a cast-iron inner cylinder. Throughout their extra wide operating range, these new R-C meters assure greater accuracy and improved performance in handling a wide variety of gases.

The development of this new meter is another example of R-C's specialized experience of more than 100 years in the design and application of air and gas handling equipment.

Write us for additional information and data sheets about these new Roots-Connersville meters for 600 psig service.

ROOTS-CONNERSVILLE BLOWER
DIVISION OF DRESSER INDUSTRIES, INC.
260 Oklahoma Ave., Connersville, Indiana. In Canada — 629 Adelaide St., W., Toronto

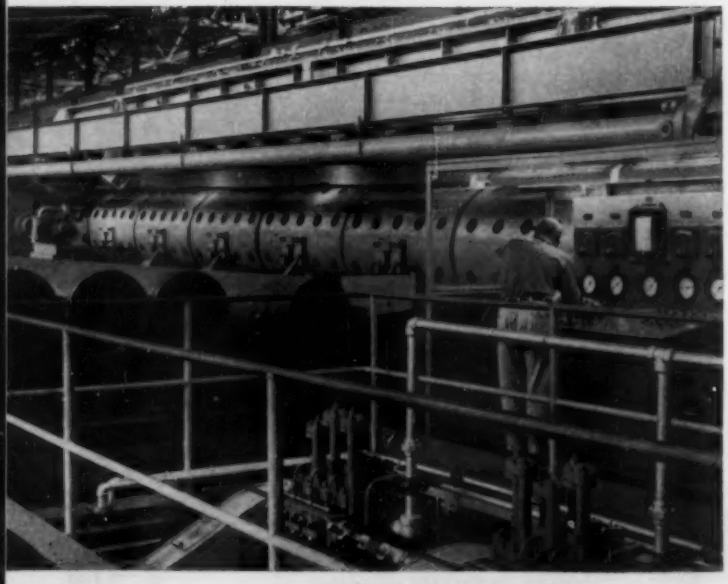
FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Industries near Hot Springs have a new and greater source of natural gas to rely on with the completion last fall of Arkansas Louisiana Gas Company's newest addition to their extensive pipeline system.

Almost a hundred miles long, the new 16-in. line starts from Aetna Field in western Arkansas and runs almost straight-a-way southeast over Magazine Mountain to terminate at Ark-La's mainline junction near Jones Mills in central Arkansas. The Bethlehem electric resistance-weld pipe used in the line met the .250-in. wall, API 5LX, Grade X-46 specification in every length, and successfully passed the hydrostatic test of 1,000 psi, full operation pressure.

On the highest peak in Arkansas or under the streets of St. Petersburg

You can count on Bethlehem line pipe



Each length is up to specs
True to round and bevel
Passed "OK" by our thorough inspection staff

For top-quality line pipe, call or write:

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Export Distributor: Bethlehem Steel Export Corporation

LINE PIPE TO 42-IN. OD. At Steelton, Pa., we produce hydraulically-expanded electric-fusion-weld API pipe from 18-in. to 42-in. OD in 40-ft lengths with walls to ¾-in. in all diameters. Electric resistance-weld pipe from 5⅜-in.to 16-in. OD in lengths to 60 ft, and Beth-Co-Weld continuous buttweld pipe from ½-in. nominal to 4½-in. OD are produced to standard API line pipe specifications on our modern pipe mills at Sparrows Point, Md.

The City of St. Petersburg added to their natural gas distribution system last summer with the installation of a new 12-in. line. Laid in sandy soil along tree-shaded streets, the line went in quickly and tested out perfectly, all due to three factors: sound planning by Stone & Webster Service Corporation, New York, N. Y.; expert pipe-laying practices of Aldridge-Poage, Inc., Lexington, Ky. (now operating under the name, Poage Construction Company, Inc.); and the uniform high quality of Bethlehem electric resistance-weld steel pipe. Industrial Supply Corp., Tampa, Fla., was the pipe jobber.

BETHLEHEM STEEL

BETHLEHEM STEEL

Foxboro Capacity Dynalog* Recorder, located upstream from receiving station, records dielectric constant of pipeline product — telemeters it ahead to delivery point.

New Accuracy in Interface Detection!

Unique Foxboro System profiles interface in advance — helps reduce product contamination at switch-over

Now your pipeline dispatchers can accurately chart the shape of an interface in advance — pinpoint their switch-over of product runs!

The Foxboro Pipeline Interface Detection System is based on the fact that even slight differences in grades of petroleum products have measurably different dielectric constants. Sensitive capacity Dynalog* Recorders measure this difference, both at the pipeline delivery station, and at a point one or two miles upstream. Foxboro Teletax* Telemetering brings the two measurements together on a single chart at the delivery station.

From the shape of the upstream record, the dispatcher selects the best cut point well before the interface arrives, and sets index at this point. When station interface record matches index, switch-over is made.

Foxboro Interface Detection eliminates sampling and guesswork — holds product contamination and loss to a new minimum. Systems in use today include both dual-measurement and single-measurement systems. Ask your nearby Foxboro Field Engineer about them, or write for Bulletin 20-11. **The Foxboro Company, 382 Norfolk St., Foxboro, Massachusetts.**

*Reg. U.S. Pat. Off.

2-pen Capacity Dynalog Recorder, at delivery station. One pen records dielectric interface measurement telemetered from upstream station. Second pen records measurement at delivery station. From upstream record, dispatcher selects best cut point, and aligns index with this point on chart. When second pen matches index, switch-over takes place, either automatically or manually.

FOXBORO
REG. U.S. PAT. OFF.

INTERFACE DETECTION SYSTEMS

Based on 27 years' experience pumping LPG and 12 years' pumping propane here is what Phillips has learned about . . .

Handling Propane By Pipeline

F. B. Neptune
Vice President
Phillips Pipe Line Company

DURING THE LAST few years great interest has been manifested by the pipeline segment of the industry in the matter of LPG transportation. Interest appears to be particularly keen concerning pipeline transportation of propane.

This is understandable in light of the immense increase in marketed production of LPG, starting about 1942.

Marketed production of LPG for the last 34 years is plotted in Fig. 1, and it will be noted that in 1958 some seven and a half billion gallons were marketed. It appears likely that more and more of this large volume ultimately will be transported from manufacturing areas to consuming areas by pipeline.

We have had many inquiries from pipeline people who are interested in our experience in pumping and handling this product. We feel that it all adds up to the fact, that while only a comparatively few pipeline systems are handling LPG today, many pipelines will be handling it in the not too distant future.

History of LPG Transportation[1]

Phillips Petroleum Company and Phillips Pipe Line Company have been transporting butane by pipeline since 1931 and propane since December 1947. We began handling propane in large volumes in June 1952 on our system from Borger, Texas, to East Chicago, Indiana. Since 1947 we have pumped approximately 33,000,000 bbl of propane.

Some of our earlier experiences may be of interest to those of you who are now pipelining LPG or who contemplate doing so in the future.

When our original 8-in. line was built from Borger, Texas, to East St. Louis, Illinois, in 1931, the line, as was the general practice at the time, was tested with water. Because all horsepower on the line was provided by butane-burning gas engines, butane was put into the line immediately behind the test water so the butane could be drawn off as engine fuel.

Although this sequence of scheduling was desirable as a means of supplying the initial fuel requirement to the pumping stations without having to haul it to remote locations by truck, it created a number of serious problems. Line scale cut out the pump packing, permitting large volumes of butane to escape in the pump rooms and creating hazardous conditions at nearly every station.

In those early days our operators spent more time in repacking pumps than in any other phase of the operation.

Furthermore, when the butane and water got into the hilly section of Missouri, between Paola and St. Louis, we found we had, in effect, created a series of U-tubes with butane in one leg and water in the other. At one time we had 1000 psi discharge pressure at Paola station and zero pressure a few stations downstream. Obviously nothing was moving. To get the stream moving it was necessary to tap the line in all the low places and draw down the water. With some butane present, extreme frosting and freezing resulted and for

[1]See also:
Roach, D. A., "Pipeline Transportation, Storage, and Shipment of Liquefied Petroleum Gas," presented at API Products Pipe Line Technology Conference, Atlanta, Georgia, May 21-23, 1951. Published in *The Petroleum Engineer*, Reference Annual (July 15), 1951; *The Oil & Gas Journal*, November 8, 1951.
Boyd, J. W.; Richardson, J. O.; and Roach, D. A., "Propane Transportation and Storage on a Products Pipeline System." Presented before API Annual Meeting, Chicago, November 9-10, 1953. Published *Oil & Gas Journal*, November 16, 1953; *The Petroleum Engineer*, Reference Annual (July 15), 1954.

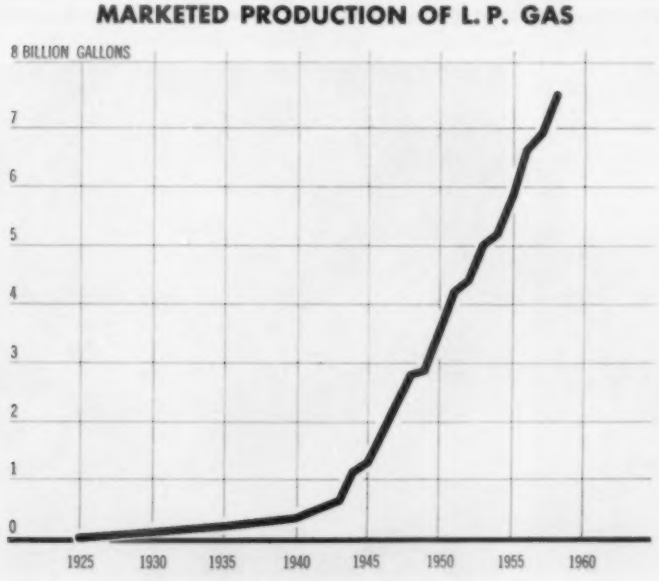


FIG. 1. Marketed production of LP-Gas.

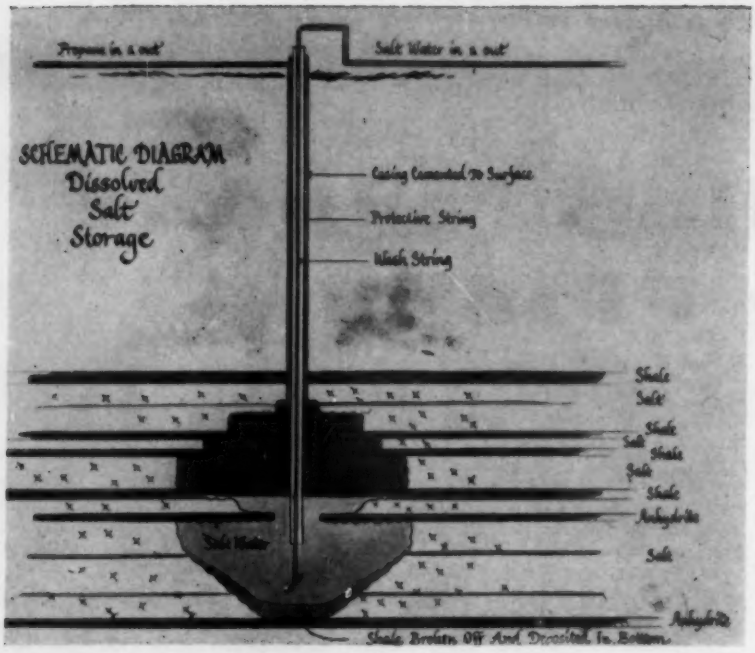


FIG. 2. Schematic diagram of dissolved salt storage cavern for LPG.

a time we were more in the ice business than in the pipeline business.

This early and rather hectic experience is recounted for the benefit of those who may find it necessary or desirable to test a new line with water where it is planned to put the line into LPG service. We would strongly recommend that, if the line must be tested with water, a heavier product, such as gasoline or kerosine, be put through the line before introducing butane or propane.

Storage for Propane

Storage for propane at pipeline origin and at terminals can be either aboveground or underground. Usually, regardless of the amount of underground storage, some aboveground storage must be provided for quality control and to maintain the desired feed rate to the pipeline. Normally it will be expensive and impractical to attempt to feed a high-volume pipeline from an underground source. This would be particularly true if the product must be re-fractionated and dried as it comes out of the underground.

Several types of storage are commonly used today for storing propane along pipelines. Perhaps the most widely used type of high volume storage is the underground cavern washed from a salt bed. While this type of storage is relatively inexpensive, the location, of course, is limited by the availability of suitable salt strata. Successful underground caverns also have been mined in suitable hard rock or shale formations. Conventional aboveground storage is expensive but has the advantage of flexibility as to location and lends itself much better to quality control.

Fig. 2, 3, 4, 5, and 6 show typical storage facilities of several types mentioned above.

Equipment at Origin

Other than pressure storage, no special equipment is required at the originating pump station. When propane is batched with other products of lower vapor pressure, however, the feeder or station booster pumps must have sufficient head to overcome the vapor pressure of propane at the highest temperature at which it will be fed to the originating station. A typical commercial propane has an NGAA vapor pressure of 85 psi at 50 F and 190 psi at 100 F. Normally it is necessary to have a high head pump only for the products that will displace propane in the feeding cycle. For example, if butane is always used as a buffer for propane, the butane feeder pump should have a head sufficient to overcome the vapor pressure of the propane. Similarly, the feeder pump handling material following butane must have a head sufficient to overcome the butane vapor pressure.

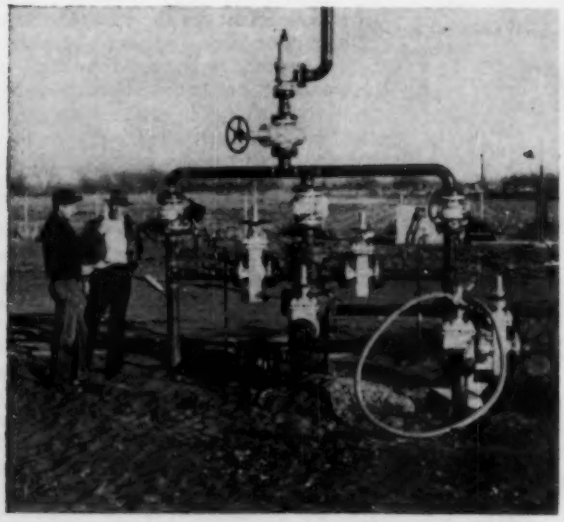


FIG. 3. Typical aboveground piping, salt wash cavern storage for LPG.

FIG. 4. Mined LPG cavern under construction.

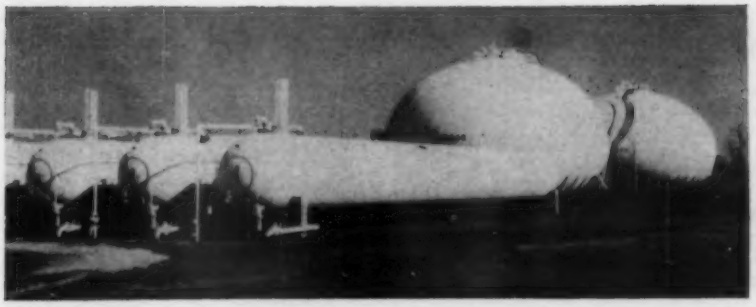


FIG. 5. Conventional aboveground propane storage (foreground).

Pumping Characteristics of Propane

Propane requires moderate pressure to maintain it as liquid in the line. Depending upon the upstream profile and the temperature of the pumpage, station intake must increase as propane approaches.

A table can be prepared setting out the minimum intake pressure for various temperatures. If the vapor pressure of the propane is likely to vary slightly, due to its composition, an allowance must be made to be on the safe side.

Another method is to install a propane vapor pressure tester at each pump station. A simple, but effective and inexpensive assembly, for determining the approximate vapor pressure of the product passing the station is shown in Fig. 7 and is operated as follows:

The station operator first receives the head end of the propane slug at some predetermined pressure that would be on the high or safe side. The operator can then find the minimum allowable intake pressure by these steps:

1. Open the expansion valve wide open and note the temperature on the dial thermometer.
2. Check the pressure gage against the station suction pressure to be sure the gages are in reasonable agreement.
3. Throttle the expansion valve, reducing the pressure on the gage by 5 psi steps, noting the temperature at each step.
4. When the temperature starts to drop, vaporization is taking place. Note the pressure on the gage and then operate with an intake pressure about 20 psi greater.

Propane is highly compressible. At 60 F a pressure change of 1000 psi will compress it approximately 4 percent, as compared to less than 1 percent for products in the motor fuel range. On a loaded or fully packed line, this compressibility, although troublesome from a metering and measuring standpoint, is beneficial from a safety standpoint in that the propane slug serves as a resilient element in the stream and tends to reduce shock in case of sudden horsepower loss or in case of a valve being closed suddenly against flow.

Because of its low specific gravity, centrifugal pumps operating on propane produce less differential than is the case with heavier products. In case of variable speed prime movers, this loss of differential can be partially compensated for by operating the prime mover at increased speed while propane is passing the station.

A pipeline system with motor-driven centrifugal pumps will suffer some drop in throughput when pumping propane from both lowered pump differential and the necessity of holding high intake pressures. This deration will vary with slug size, station spacing, number and location of intermediate bleed-off terminals, etc., but will be less than deration from the distillates.

Buffering Practices — Contamination

It has been our experience that the internal condition of the pipeline bears an important relationship to the amount of contamination that can be expected while pumping LPG. We are speaking of contamination in the sense of very small quantities of contamination extending completely through, or largely through, an entire batch of propane or butane rather than the usual interface of a comparatively few barrels normally experienced between products. This so-called "slug contamination" must be considered because of rigid residue specifications.

The interior of our 6-in. Borger-Denver pipeline, laid in 1947, is known to be almost completely free of internal corrosion. This is because the line has been continually dehydrated and the "C" Factor has remained equal to the original new pipe value.

On this line we are able to pump comparatively small slugs of propane, buffered by only a few barrels of butane, along with heavier products such as stove oil and furnace oil, approximately 355 miles to Denver and deliver on-specification propane at our Denver terminal.

On our Borger-Chicago line we have a somewhat different condition. The greater part of this system consists of pipe 26 to 28 years old, which was not adequately protected internally and is known to be rather heavily scaled. The Borger-Chicago system actually consists of two parallel pipelines with common pumping stations and here we have found it desirable to limit LPG

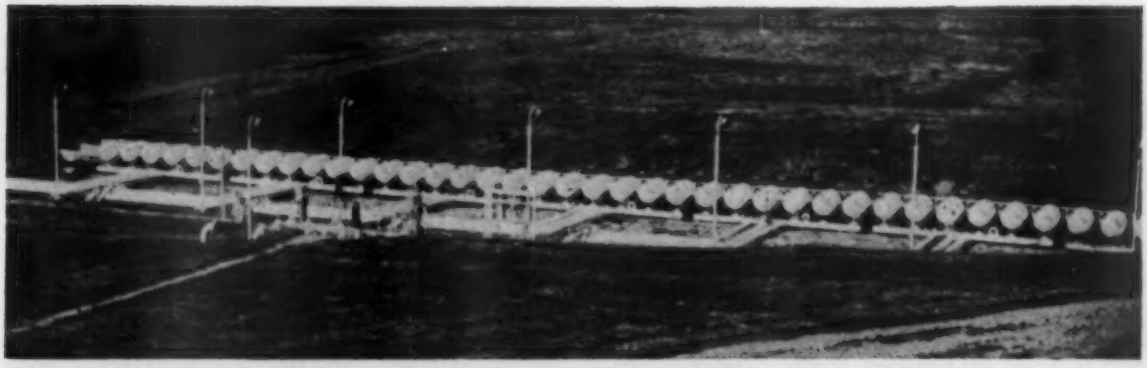


FIG. 6. Propane storage fabricated from pipe — 42 tubes 30 in. by 1143 ft. Net capacity: 34,000 bbl.

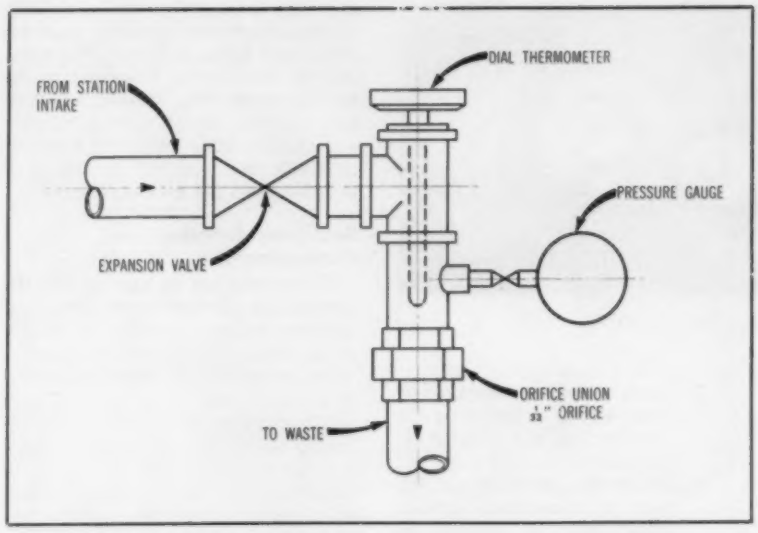


FIG. 7. Propane vapor pressure tester.

pumpings to one line and to pump the distillates in the other line. Natural gasoline, motor fuel, aviation gasoline, and motor fuel base, however, are pumped in either line.

It has been our experience that with a heavily scaled line, the oils tend to remain in the scale and are released into the LPG as "slug contamination" extending through all, or a large part, of the LPG batches that follow.

In cases where it has been necessary to pump LPG through the internally scaled pipe, large buffers of natural gasoline were pumped ahead of the LPG batch; however, it is recognized that many pipeline carriers will not have available such large slugs of natural gasoline to serve as a washing agent ahead of the LPG slug.

In a system handling all finished products, as opposed to a system handling blending stocks and completing the blending at the terminals, there is a problem of disposal of the motor fuel-butane interface and the butane-propane interface. If the motor fuel is delivered to the carrier at maximum volatility, no butane blending can be tolerated at the terminaling point. Therefore, unless the shipper is in a position to furnish occasionally a sub-specification motor fuel, it is not possible to blend off the motor fuel-butane interface and it must be disposed of otherwise. The butane-propane interface generally can be sold as a mix, if it is on-specification otherwise.

By keeping the distillates out of the line handling LPG and by proper buffering, we have found it possible to deliver on-specification propane at all of our intermediate terminals between Borger, Texas, and Kankakee, Illinois. The most remote intermediate terminal is 680 miles from origin and to date we have experienced no difficulty in successfully taking off heart cuts of specification product after transporting propane through 8, 10, and 12-in. pipe.

Special Safety Equipment

For safe operation in pumping a highly volatile product such as propane, mechanical seals are strongly recommended for all main line centrifugal pumps. On our Borger-Chicago system, which utilizes centrifugal pumps exclusively, failure of conventional lead and graphite ring packing when pumping butane was a source of constant trouble and represented a real hazard when the packing failed. After some experimenting we found that the use of force-feed lubricators to feed lubricating oil under pressure to a lantern gland placed in the middle of the seal ring assembly, largely reduced packing ring failure and considerably reduced gland leakage.

When it became necessary to transport propane on the Borger-Chicago line in 1952, however, it was found that this method of packing lubrication was not at all satisfactory and packing failure was too frequent to be tolerated. Fortunately, at about that time, a research and testing program, sponsored jointly by one of the major products pipeline companies, two pump manufacturers, and several manufacturers of mechanical seals, had resulted in the near-perfection of a partially balanced mechanical seal that would hold propane at the pressures (1100-1200 psi) at which our line was operating.

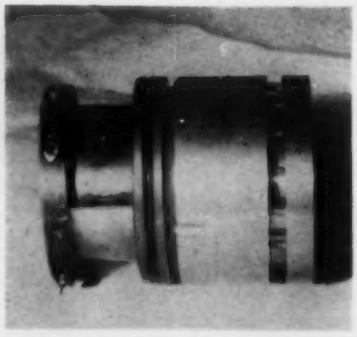


FIG. 8. Mechanical seal for main line centrifugal pump.

After pumping one slug of propane from Texas to Illinois, we concluded the operation was too hazardous with pumps equipped with conventional lead-graphite packing. We immediately began installing mechanical seals and until the mechanical seals were installed, propane slugs were reduced in size and stations were shut down while propane was passing. (See Fig. 8 and 9.)

The pipeline carrier may or may not own or control aboveground storage for propane. As a matter of safety, however, it is recommended that all aboveground storage of this type be equipped with remotely controlled internal valves. These valves can be closed from a remote location in event of emergency. We have employed both hydraulic and electrical types. Both have been found satisfactory.

Occasionally it will be necessary to take a main line unit off the line while propane is passing the station. If it is necessary to work the pump, the product trapped in the pump and the pump leads must be removed. We have found it desirable to equip each pump in propane service with a blow-down line extending to a riser that is a safe distance from ignition sources. As each gallon of propane will convert to approximately 36 cu ft of vapor, it readily can be seen that without such equipment the handling of such a large volume of vapors would create a problem.

Special Tariff for Propane

Phillips Pipe Line Company has published a special tariff for the transportation of propane. This tariff provides the same rate as for other products, but specifies that the shippers will provide all storage and related facilities for handling propane at origin and destination. It also provides a 2 percent loss allowance for the benefit of the carrier. Because of the high cost of pressure storage, it would be necessary that this cost be reflected in tariff rates if the carrier provided such storage.

Leak Experience

Although, as mentioned previously, we have handled 33,000,000 bbl of propane in the last eleven years through

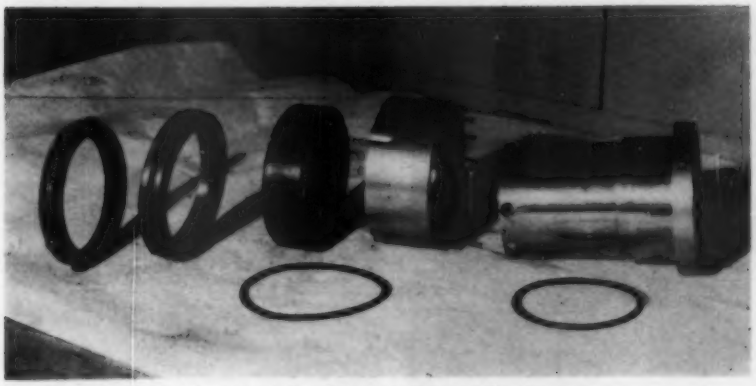


FIG. 9. Exploded view of mechanical seal for main line centrifugal pump.

systems containing pipe part of which has been in the ground since 1931, our leak experience has been reasonably good. The only two potentially hazardous leaks we have experienced were not caused by failure of the pipe due to corrosion, but by road-working equipment cutting the line.

We have had only one major pipe failure charged to corrosion while propane was in the section, and this failure occurred in a remote area. We have never had a fire or explosion on our pipeline systems caused by propane. This includes not only the transportation phase, but also all other handling such as storage and loading at terminals. Actually, with suitable equipment and proper handling, we feel propane offers no more hazard in the pipeline and less hazard at terminals than other products.

Leak Repair Practice

Unless it occurs in an area where even minor escape of vapors creates a hazard, it has been found desirable, in the case of a small leak occurring in a section containing butane or propane, to pump the product by the leak area and make repairs when a less volatile product is passing. This is because the ground at the leak location is invariably frozen from the cooling involved in evaporating the leaking propane or butane and uncovering the pipe is difficult, slow, and somewhat hazardous. (See Fig. 10.)

Large leaks, of course, require a shut down, but this does not stop escape of product. Generally, in case of a large leak, the only recourse is to shut down, eliminate all possible sources of ignition, move people out of the area, and close all roads.

Of course, any block valves on each side of the leak area should be closed as soon as possible. If there is considerable distance between block valves, the hazard in the leak area can be reduced by tapping the line at a safe location between the blocked valves and flaring the product. Also, if a water source is available, water may be introduced upstream of the leak and pumped until the volatile material is pushed past the down-stream block valve. If the leak is large enough, all volatile material will have escaped before anything can be done.

Because, as mentioned before, the ground will be frozen in the leak area, we have found it advisable, in order to reduce downtime, to stock pipe and the necessary fittings at strategic locations along the system so we can cut in and lay a temporary line around the leak location without waiting for the line cover to thaw.

Perhaps the most troublesome type of leak that will be encountered is one that is too large to allow pumping by a less volatile following product and yet not so large but that many hours, or even days, would be required for the product to vent itself between any valve closures that might be effected. For leaks in this category, tapping and plugging machines may be used to confine the product loss to a relatively small section of the line. Although we have had no occasion to use this equipment under emergency conditions, we have experimented with two well-known makes of tapping and plugging equipment, and have found that both are effective in blocking off propane under moderate pressure, i.e., the plugging equipment will hold the vapor pressure of the propane, plus a reasonable static head.

FIG. 10. Propane leak area. These men are standing on an ice crust approximately 12 in. thick and 150 ft in diam. Heavy bulldozer was unable to cut through this ice crust.

Summary

Considerable interest is presently being manifested in handling LPG in pipelines, undoubtedly as a result of the recent immense increase in LPG marketing. Volume has doubled in the last eight years and reached approximately seven and a half billion gallons in 1958.

Phillips has been pipelining butane for 27 years and propane for 12 years. No particular pumping problems were encountered except that it was necessary to convert to mechanical seals to pump propane. It is necessary to carry higher pump intake pressures to overcome the high vapor pressure of propane. This, coupled with low specific gravity, causes a slight loss in pipeline rates.

When pumping LPG through the same lines with distillates, especially if internal scale exists, care must be taken to provide suitable buffers to prevent contamination.

Tankage should be provided by the shipper. If the pipeline has to provide storage, tariffs would be higher to pay for this expensive storage. Underground storage in caverns developed in salt strata or mined in suitable limestone or shale can be used; however, some aboveground steel storage is usually needed.

Some additional precautions are needed when repairing leaks in the presence of LPG. Considering all factors, we consider propane offers no serious operating problems and is no more hazardous to handle than other products in a pipeline. ★ ★ ★

CONSTRUCTION FEATURE

Michigan Wisconsin's loop line was successfully laid under the Missouri River near Rulo, Nebraska, despite high water. The original main line crosses on a highway bridge.

American Natural Subsidiaries Complete Two Major Projects

Michigan Wisconsin's $40,000,000 program will add 80,000,000 cu ft a day to capacity — American Louisiana installing two new stations

THE American Natural Gas Company system recently completed two major expansion projects in its effort to satisfy the constantly growing demands of its market areas.

The largest project was carried out by the Michigan Wisconsin Pipe Line Company, a subsidiary, which operates a transmission system from the Hugoton field in Texas to Wisconsin and Michigan.

In order to take 80,000,000 cu ft of gas a day from the newly developed Laverne gas field in northwestern Oklahoma, the company embarked on a $40,000,000 construction program. Starting in the fall of 1958, Michigan Wisconsin installed 40 miles of 20-in. line from its main line to Laverne and 130 miles of gathering system in the field. The pipeline is receiving gas from 120 wells producing from four formations.

In March 1959 the company began construction of 374 miles of loop lines and the addition of 20,400 hp to 10 of its existing compressor stations. The 11 main line 24-in. loops, averaging about 35 miles in length, are located in 6 of the 10 states through which the pipeline passes. These facilities are now in operation.

Ford, Bacon and Davis Construction Corporation was retained to supervise and inspect the construction of the loop lines and build the additions to the compressor stations. R. H. Fulton and Company laid six loops in Kansas, Nebraska, and Missouri. Panama-Williams Corporation did three loops in Iowa and Illinois. Somerville Construction Company laid two loops in Michigan. A 21-mile, 16-in. loop line in Wisconsin was installed by G. E. T. Construction, Inc.

Normal construction problems were intensified because of abnormally heavy rains during the spring. Construction had to get underway early, however, in order to finish the job by mid-July to meet gas purchase contract provisions. One of the most difficult jobs was the Missouri River crossing where Pentzien, Inc., had to fight flood waters while digging and dredging the 3200-ft approaches and underwater ditch.

American Natural's other pipeline subsidiary, American Louisiana Pipe Line Company, expanded its capacity with the construction of two new compressor stations at a cost of $6,081,000, an 8000-hp station in northeastern Louisiana and a 10,000-hp station in southwestern Tennessee.

The new stations will permit American Louisiana to deliver an additional 43,000,000 cu ft of gas a day, mainly from fields in Cameron Parish, Louisiana. These stations went into operation at the end of the year.

Michigan Wisconsin is also planning a further expansion and filed an application with the FPC in conjunction with Midwestern Gas Transmission Company, which will purchase gas from Trans-Canada Pipe Lines, Ltd. The permit has been granted.

Midwestern proposes to purchase 204,000,000 cu ft a day from Trans-Canada at the international boundary near Emerson, Manitoba, and construct a pipeline from there to Marshfield, Wisconsin.

Michigan Wisconsin plans to construct an extension of its existing system from Appleton, Wisconsin, to Marshfield where it would purchase 158,000,000 a day from Midwestern. The company would construct 258 miles of 16, 20, and 24-in. lines and 118 miles of 4, 6, and 8-in. lines. It would also build a new 5280-hp compressor station and 23 measuring stations.

The Canadian gas would enable Michigan Wisconsin to supply eight utilities for service to 28 communities in Wisconsin and several in Michigan, which presently do not have natural gas. All have requested service from the company, and are within its market area. Michigan Wisconsin would also increase needed deliveries to its present utility customers. Total cost of these facilities is estimated at $24,000,000. ★ ★ ★

Pipeline Projects

Michigan Wisconsin, Northern to Expand

Northern Natural Gas Company has signed an agreement with Michigan-Wisconsin Pipe Line Company whereby the latter will purchase 75,000,000 cu ft daily of natural gas from Northern at a point near Janesville, Wisconsin, commencing about November 1, 1960, for use in the Milwaukee, Madison, and Detroit areas.

Northern plans to build a 10-in. line from its present eastern terminus at East Dubuque, Illinois, to Janesville, a distance of about 80 miles, as well as 154 miles of loop lines and additional 14,500 compressor hp to render this service. Total estimated cost of these facilities is $24,922,000.

Michigan Wisconsin seeks authority to add a new 3000 hp compressor station near Janesville and to build 29 miles of main line loop, at an estimated cost of $4,363,000, to take the gas from Northern.

In addition to filing applications with the Federal Power Commission on this joint project, both companies have filed separate applications for further expansion of their respective systems.

Northern proposes the construction of 103 miles of main line loops, 20 miles of branch line loops and the addition of 17,360 compressor hp at an estimated cost of $16,614,000 to enable it to make an additional 40,000,000 cu ft per day of gas available to Northern Illinois Gas Company and 38,000,000 cu ft per day available to other presently serviced utility customers.

Michigan Wisconsin proposes the construction of $44,876,000 of facilities to permit it to increase by 100,000,000 cu ft per day its takes from the Laverne field.

Seek Florida Line Increase

Seeking to increase gas capacity in Florida, Houston Texas Gas and Oil Corporation has filed an application with the Federal Power Commission involving five new compressor stations and 199 miles of 2 to 6-in. pipelines.

Another Houston Corporation subsidiary, Coastal Transmission Corporation, also filed an application to construct 81 miles of 3 to 10-in. pipelines and compressor stations between Texas and Louisiana.

Construction costs on the facilities would total about $18,750,000.

Iowa Products Terminal

Great Lakes Pipe Line Company has scheduled construction this spring of a delivery terminal that will provide improved petroleum product transportation for a heavy consuming area in Iowa.

The terminal, to be located at Waterloo, Iowa, will become the fifth in the state for Great Lakes and is part of the $10,000,000 expansion program begun by the company in 1959.

The new terminal will be served by an 8-in. line connecting to the company's lines at Grinnell, Iowa, a distance of approximately 58 miles.

PLGS Names Contractor, Starts "Prelim" Work

January was a month of preliminary construction work on Pacific Lighting Gas Supply Company's $17,300,000, 116-mile natural gas transmission line that will meet Transwestern Pipeline Company's system now well underway.

Pacific Pipeline Construction Company was awarded the double-jointing and coating contract, and will construct the pipeline in a joint venture with Engineers Limited Pipeline Company. Preliminary right-of-way work began January 4. Double jointing and coating at Minneola, near Daggett, California, started January 11.

Engineering specifications for the 116-mile pipeline, stretching from the California-Arizona border seven miles north of Needles to a point near Newberry, 20 miles east of Barstow, call for a twin crossing 14 ft below the bed of the Colorado River, with two 24-in. lines located 500 ft apart. Another contractor will construct the river crossing.

At Newberry, the 34-in. PLGS pipeline is scheduled to be connected to a proposed 36-in. pipeline of Southern California-Southern Counties Gas companies which will take the new out-of-state gas to the Los Angeles basin. An application for a certificate of public convenience and necessity to build this latter line has been filed with the California Public Utilities Commission.

When completed in the summer of 1960, the PLGS line will swell gas supplies for the southern California market by 300,000,000 cu ft a day. Both the PLGS and Transwestern lines have been designed so that they may be economically expanded to carry as much as 640,000,000 cu ft of gas a day when southern California fuel requirements call for the increased supply.

New Indiana Storage Field

A fourth underground gas storage field in Indiana is under development by Texas Gas Transmission Corporation.

A period of about four months will be required to remove the sour, unmarketable gas by flaring from the 1000-acre White River gas field in Pike County, Indiana. Gas supplies purchased in Texas and Louisiana will be used in refilling the reservoir.

Texas Gas has been developing underground storage in southern Indiana since 1945, and presently owns and operates the Oaktown storage field in Knox County, the Alford in Pike County, and the Wilfred in Sullivan County.

Trunkline Proposes Sale With Panhandle Carrying

The Federal Power Commission has been asked to authorize sale of gas by Trunkline Gas Company to Consumers Power Company on an interim basis, with Trunkline delivering to Panhandle Eastern Pipe Line Company at Tuscola, Illinois, and Panhandle transporting and delivering such gas to Michigan Gas Storage Company for Consumers.

Michigan Gas Storage and Panhandle filed concurrent applications.

Trunkline seeks to initiate quick service to Consumers, commencing with approximately 10,000,000 cu ft per day.

Transwestern Seeks Additional Facilities

A construction application for additional facilities to annex to Transwestern's pipeline system in excess of 500 billion cu ft of additional gas reserves, from some 49 additional gas purchase agreements on which producers previously filed certificate applications, is now before the Federal Power Commission.

These facilities, estimated to cost $5,834,000, will be in the Texas and Oklahoma Panhandle areas and the Permian Basin areas of West Texas and New Mexico.

Transwestern requested an early FPC decision. Construction of the additional facilities during initial construction of the main line, which is now underway, is desirable, it was pointed out.

Projects

Bayou Line To Undergo Modernization In 1960

The Bayou Pipe Line System, now being operated by Service Pipe Line Company, will undergo an extensive modernization program beginning early in 1960 and including installation of control, telemetering, and safety equipment, as well as remote reading tank gages and monitoring equipment.

The participants, including Service, which recently purchased a part interest and signed an operating agreement, formulated the modernization plans for the 300-mile products line, constructed in 1942 when the United States needed more capacity to move petroleum products to the eastern seaboard.

Facilities involved in the modernization program include five electrically-operated relay stations located near Hankamer and Fannett, Texas, and Buhler, Basile, and Cortableau, Louisiana, which are presently pumping more than 50,000 bbl a day to the Plantation Pipe Line system in Baton Rouge, Louisiana, and other outlets, from refineries at Texas City, Pasadena, Deer Park, Baytown, and Port Arthur, Texas.

Facilities at the two Texas stations will be controlled and monitored by employees at the terminal in Baytown, while personnel at the Port Neches, Texas, terminal will control and monitor the three Louisiana stations. In the event of mechanical, electrical, or hydraulic failure, the protection devices scheduled to be installed will shut down the proper station and signal the terminal involved.

Six "Budgets" Filed Totaling $11,745,000

Unrelated budget-type construction applications totaling $11,745,000 have been filed with the Federal Power Commission by six companies.

Texas Eastern Transmission Corporation proposes 1960 construction totaling $4,000,000, with the cost of any single project limited to $500,000.

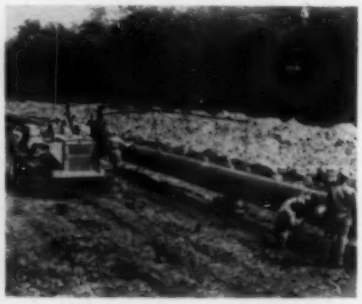
Arkansas Louisiana Gas Company would construct during 1960 facilities having a total cost limited to $2,745,000, with the cost of any single installation not to exceed $500,000.

Colorado Interstate Gas Company is seeking FPC authority to construct facilities in 1960 at a total cost of $1,000,000, with the cost of any single project limited to $200,000, to enable it to take natural gas purchased from independent producers in the general area of its existing system.

United Gas Pipe Line Company proposes to construct $750,000 facilities in 1960 to enable it to make new direct industrial sales of natural gas, with the cost of any single connection limited to $200,000.

Consolidated Gas Utilities Corporation proposes to construct during the fiscal year ending October 31, 1960, facilities whose total cost would not exceed $750,000.

Columbia Gulf Transmission Company seeks to build up to $2,500,000 of facilities in 1960, with the cost of any single project not exceeding $500,000.



C. S. LeNoir Construction Company welds 60-ft lengths in the final stages of Trunkline Gas Company's 57-mile, 30-in. line from Polk, south to Brownsville, Tennessee, paralleling another 30-incher owned by Trunkline. Under good operating conditions, 10,000 to 12,000 ft of pipe are laid every 10 hours, while rough terrain or swampy areas reduce this figure to 7,000 to 8,000 ft.

Crew On Louisiana Loop

Columbia Gulf Transmission Company personnel that have been working on the company's 41-mile, 24-in. loop between Erath Junction and Lake Sand Junction, Louisiana, include: R. V. Lambert, district superintendent; George Cadle, chief inspector; Paul Chruma, Jack Keen, welding; Chris Martin, ditching; B. A. Schoolar, coating yard; Sam Howell, dope; Leslie Chruma, valve setting; Allie Young, casing and canal crossings; W. L. Smith, clearing and grading, M. F. Ordogne, clean-up; and Kenneth Copes, Kelly Johnson, Harold Utterback, clerks. Al Gautreau is project's engineer.

A Western Pipe Line, Inc., spread has been working east from Erath, with J. C. Oliver as project manager and Jack Fraley as superintendent.

Seeks Import At Niagara

Tennessee Gas Transmission Company has asked Federal Power Commission authority to receive deliveries of up to 200,000,000 cu ft of gas per day on an interruptible basis from Trans-Canada Pipe Lines, Ltd., at the International Boundary near Niagara Falls, New York.

Mile of Aluminum Pipe

Columbia Gulf Transmission Company's newly-constructed 7.2-mile Calcasieu Pass field line, includes a mile of aluminum pipe and an all-aluminum measuring station. The 6-in. line runs from Mud Lake on the West Lateral to wells near Cameron, Louisiana.

International Notes

Possible extension of the Sui-Multan gas transmission line farther northward to the former provinces of the Punjab and the North West Frontier is now under study. It is understood that any plan evolved is likely to be in respect of northern development as a whole in Pakistan's second Five Year Plan and that piecemeal extensions will not be recommended.

In Brazil, a 35-mile, 12-in. crude line from Buracica to Candeia is planned by Petrobras, S. A., with Trechint, Inc., awarded contract for construction.

A 240-mile, 8-in. Iranian products line, extending from Rey, near Tehran, northeast to Sharud, will be constructed beginning early this year by Williams Brothers Company for the National Iranian Oil Company.

The West German steel and pipe manufacturers, Phoenix-Rheinrohr-International and Mannesmann-Export, have announced a $15,000,000 order, in which they each participate with 50 percent, to build three pipelines: One, from Suez to Cairo, for kerosine; another, for fuel oil, from Alexandria to Tanta; and the third, likewise for kerosine, from Alexandria to Kafr-el Dewar.

Engineering details for a 30-in. Libyan crude oil pipeline, with an initial capacity of 74,540,000 bbl a year, are being studied by Standard Oil (New Jersey).

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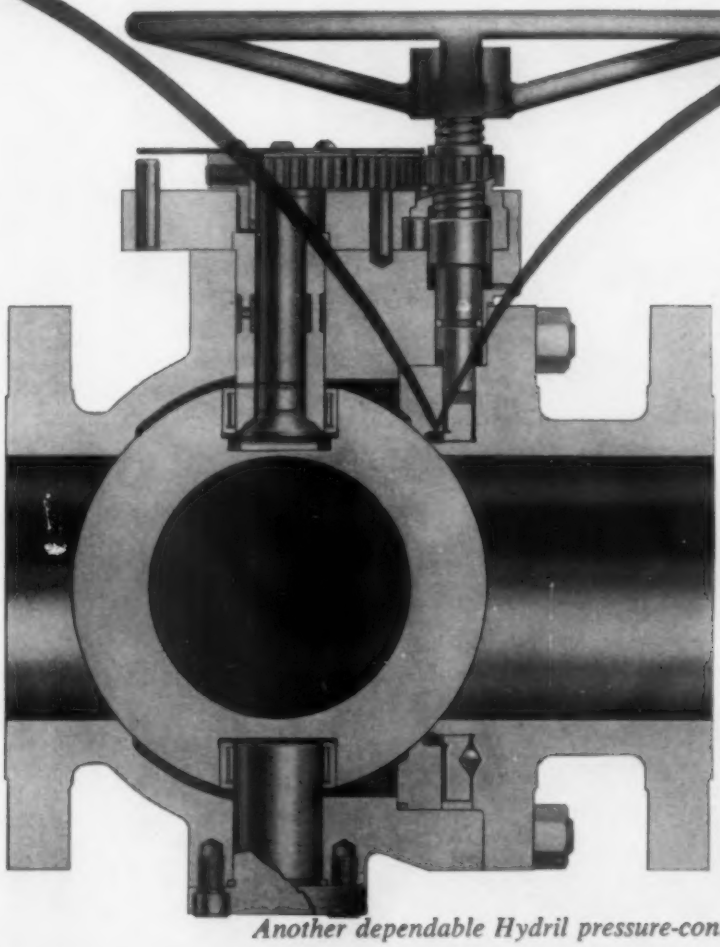
POSITIVE SHUTOFF



Hydril Ball Plug Valves achieve a positive seal against pressure from either direction because the fully enclosed packing ring is *mechanically pressed* tightly against the spherical plug and its seat after the valve is closed.

No other valve has this *controlled* port sealing feature.

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Quarter scale model of experimental gas turbine being developed by Cooper Bessemer and Pratt & Whitney Aircraft. Units should be available for use within 18 months.

How Cooper-Bessemer is teaming up with Pratt & Whitney Aircraft to develop JET TURBINE POWER for industry

The cutaway model shown is a revolutionary new concept in gas turbines. The generating unit is a new Pratt & Whitney Aircraft jet engine—a modification of the famous J-57 aircraft engine, designed for gas fuel. The companion power unit is a new Cooper-Bessemer power turbine. This combination, now in the advanced experimental stages, represents the hottest development in industrial power in 20 years. It will mean drastic economies in installations of engine-driven compressors, generators and other rotating machinery.

For example, it is expected to materially reduce the construction cost of gas compressor stations.

Plans call for this new gas turbine to be available for broad application within 18 months. In the meantime, watch for reports on further developments in this pioneering teamwork by Cooper-Bessemer and Pratt & Whitney Aircraft.

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Canadian News Notes

Peace River Wins OK To Pipe B.C. Oil

Peace River Oil Pipe Line Company's planned 255-mile, $8,608,200, 8-in. extension of its existing system to serve British Columbia oil fields has won B. C. government approval over four competing applications.

The proposed extension from Beatton River, Milligan Creek, and Boundary Lake oil fields of B. C., would supply the refineries at Dawson Creek, B. C., and Grande Prairie, Alberta, and deliver the surplus into the present system at the terminus in the North Sturgeon Lake field in Alberta. This line in turn extends southward through Alberta to connect with the Trans Mountain Oil Pipe Line Company's line at Bickerdike, Alberta.

The line's rated capacity will be 21,700 bbl per day initially, to be enlarged ultimately to carry 26,200 bbl per day.

Construction is expected to start in the spring, so that the line can be in operation by next fall.

Plans of Gibson Petroleum, Ltd., Trans-Prairie Pipe Lines, Ltd., and Pacific Petroleums, Ltd., were rejected as economically impracticable.

Opposition Gathers In Export Projects

National Energy Board hearings on several natural gas export pipeline projects, which opened in Ottawa on January 5, will be complicated by opposition in the form of interventions by two major distribution companies and 11 minor opponents.

Saskatchewan Power Corporation filed a brief asking that no export permits be granted until there is assurance of 30 years' Canadian supply by proven gas reserves. S.P.C. noted its own requirements as 4.5 trillion cu ft in this period and said it has only 1.5 trillion secured. Its brief also called for full price equality between domestic distributors and export purchasers, and urged that local utilities be given an over-riding call on export gas if any deficiency occurs during the term of an export contract.

Northern Ontario Natural Gas Company, Ltd., is opposing the Trans-Canada application principally and the other applications secondarily, on the ground that prices of gas delivered in its Ontario zones will be increased if Trans-Canada is allowed to build its proposed export pipeline in Manitoba. The argument is that the 204,000,000 cu ft per day volume will require Trans-Canada to draw on fields in which the wellhead price is higher than those now being used. This price, the company asserts, will have to be applied to Ontario deliveries as well.

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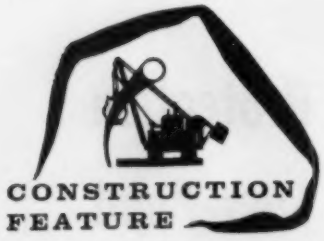
WITH THE PIPELINE CONTRACTORS



● **APV Company, Inc., 1801 Continental National Bank Building, Fort Worth, Texas.** Has been awarded contract to construct 61.4 miles of 30-in. from Pollock, Louisiana, to a point near Mangham for *Trunkline Gas Company*. Field office is in Olla. A. Vaughn is superintendent, and W. L. Huff is spreadman.

● **Macco Corporation, 14409 South Paramount Boulevard, Paramount, California.** Has prime contracts with various companies to construct pipelines in various sizes through 30-in. in California.

● **Majestic Contractors, Ltd., 408 Royal Trust Building, Edmonton, Alberta, Canada.** Has been awarded an undetermined amount of 4 through 10-in. crude oil gathering system to be constructed in the Estevan, Saskatchewan, area for *Producers Pipeline Company*. Jeff Minter is supervising at Estevan.

● **Collins Construction Company, P. O. Box 86, Port Lavaca, Texas.** Has in progress the construction of 20 miles of dual 32-in. lines for *Basrah Petroleum* from Fao, Iraq, to an offloading terminal in the Persian Gulf; and the construction of dual 12 and 24-in. natural gas pipeline river crossings for *Petroleos Mexicanos* between Pemex City and Mexico City in Mexico. For the latter, field office is in Minatitlan, Mexico, with Rug Stapleton as project manager.

● **Contracting & Material Company, 1235 Dodge Avenue, Evanston, Illinois.** Is laying 62.2 miles of 26 in. for *Trunkline Gas Company* from Tuscola to Rossville, Illinois. Two spreads will be used, under the general supervision of Jim McGill.

● **Engineers Limited Pipeline Company, 11858 San Pablo Avenue, El Cerrito, California.** Has been awarded a contract by *Trunkline Gas Company* to construct 136 miles of 26-in. pipeline from Rossville, Illinois, to the Indiana-Michigan border. H. H. Mehail will supervise the first spread at Fowler, Indiana, and Jake Cheeves will supervise the second spread at Goshen, Indiana. Has been awarded a joint-venture contract with Pacific Pipeline Construction Company for the construction of 116 miles of 34-in. pipeline for *Pacific Lighting Gas Supply Company* between Needles and Newberry, California. Lee Erlewine is superintendent.

● **R. H. Fulton & Company, P. O. Box 1526, Lubbock, Texas.** Has been awarded a joint contract with Houston Contracting Company and Western Pipe Line, Inc., to lay approximately 300 miles of 16, 12, and 10-in. trunk lateral lines in the Texas-Oklahoma Panhandle and West Texas-New Mexico area for *Transwestern Pipeline Company*. Has received a contract from *El Paso Natural Gas Company* for construction of 126 miles of 30-in. pipeline in various loops across New Mexico, paralleling the company's existing line, and has named H. A. Tinkler superintendent and has located the field office at Tatum, New Mexico. Has been awarded a contract by *Natural Gas Pipeline Company of America* to lay 28 miles of 10 and 12-in. pipe in Love County, Oklahoma, under the supervision of Bill Cohoon at Marietta, Oklahoma.

● **Grayco Constructors, Inc., P. O. Box 4147, Austin, Texas.** Has contract with *Trunkline Gas Company* to lay a 53-mile, 30-in. line between Pitkin and Pollock, Louisiana.

● **Groninger & King, Inc., P. O. Box 1381, Pampa, Texas.** Is completing 50,000 ft of 4, 6, 8, and 10-in. gas gathering system in the Texas Panhandle for *Northern Natural Gas Company*. W. G. Puckett is supervising at Pampa, Texas.

● **Hall Construction Company, 1105 N. Carlton, Liberal, Kansas.** Is working on a 330-mile, 4 through 12-in. gathering system in western Kansas for *Panhandle Eastern Pipe Line Company*. Supervising are Mike Bell and M. E. Banning.

● **The Hallen Construction Company, Inc., 4270 Austin Blvd., Island Park, New York.** Has been awarded a contract by *Algonquin Gas Transmission Company* for the installation of approximately 3000 ft of 8-in. lateral line near Farmington, Connecticut, where field office will be located under the supervision of Gene Miller.

● **Houston Contracting Company, 2807 Buffalo Speedway, Houston 6, Texas.** Has been awarded a contract by *Transwestern Pipeline Company* to lay the following: 149 miles of 30-in. from the vicinity of Corona, New Mexico, west to the vicinity of McCartys, with L. A. Young as superintendent in Corona; 55 miles of 30-in. and 89 miles of 24-in. from Corona, east to Roswell and southeast to Carlsbad, with M. L. Thompson as superintendent at Roswell; 61 miles of 20-in. and 76 miles of 24-in. from the vicinity of Fort Stockton, Texas, northwest to the vicinity of Carlsbad, New Mexico, with A. J. Slovack as superintendent at Fort Stockton; 166 miles of 24-in. from Roswell, northeast to the vicinity of Dawn, Texas; and a joint contract with R. H. Fulton & Company and Western Pipe Line, Inc., for approximately 300 miles of 16, 12, and 10-in. trunk lateral lines in the Texas-Oklahoma Panhandle and West Texas-New Mexico area. Has received a contract from *United Gas Pipe Line Company* for the construction of 11 miles of 20-in. in the vicinity of Gonzales, Louisiana, where the headquarters will be located under the supervision of R. L. Silar, assisted by R. R. Lytle. Has been awarded a contract by *Texas Gas Transmission Corporation* to lay 27 miles of 6-in. products pipeline between Woodlawn, Louisiana, and the Eunice dehydration plant, under the supervision of R. L. Silar.

● **Bechtel Corporation, 220 Bush Street, San Francisco 4, California.** Is double jointing for Engineers Limited Pipeline Company 79 miles of 26-in. pipe near Lafayette, Indiana. Fowler, Indiana, is the site of the first setup, and the second is at Pleasant Ridge, Indiana, with Arthur Rigby supervising both.

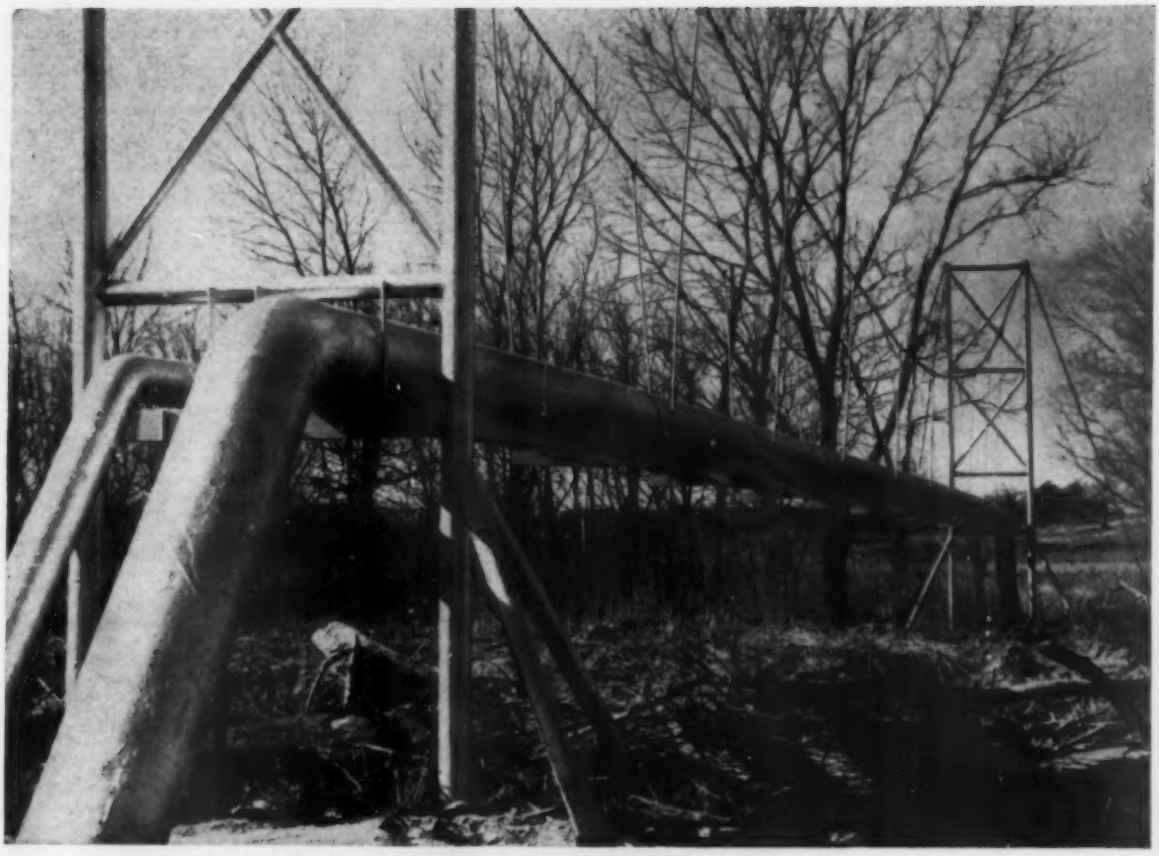
● **O. R. Burden Construction Corporation, P. O. Box 5216, Tulsa, Oklahoma.** Has underway 105 miles of 8 through 20-in. in Atascosa and Jim Hogg counties, Texas, for *South Texas Natural Gas Gathering Company*, with R. M. Jones supervising the job. Is constructing 75 miles of 6 through 8-in. line for *The Ohio Oil Company* between Albion and Samaria, Michigan, under the supervision of C. M. Hoffman.

● **Cape Construction Company, Box 423, Cape Girardeau, Missouri.** Has been awarded a contract by *Consumers Power Company* to construct 22 miles of 24-in. and 119 miles of 26-in. natural gas pipeline between White Pigeon and a point northwest of Detroit, Michigan. There are two spreads — one under Garland Mims, and the other supervised by Roy Whitworth.

● **Mannix Company, Ltd., 737 - 8th Avenue, S.W., Calgary, Alberta, Canada.** Has been awarded a contract by *Home Oil Company, Ltd.*, for the construction of 38 miles of 4, 8, and 10-in. oil gathering line; a contract by *Pan American Petroleum Corporation* to lay a 24-mile, 2 and 3-in. water injection system; and a contract by *Mobil Oil of Canada, Ltd.*, for a 6-in. crossing of the North Saskatchewan River at Drayton Valley, Alberta.

● **Pacific Pipeline Construction Company, 1632 S. Greenwood Avenue, Montebello, California.** Has received a joint contract with Engineers Limited Pipeline Company to construct 116 miles of 34-in. pipeline for *Pacific Lighting Gas Supply Company* between Needles and Newberry, California. Field office will be located at Ludlow, California.

● **Panama, Inc., 2201 Commerce Building, Houston 2, Texas.** Is working two sections on the *Trunkline Gas Company* project. The first, with M. C. "Tex" Johnson as supervisor and Marks, Mississippi, as field office, starts approximately 15 miles northeast of Lambert, Mississippi, and proceeds in a southerly direction to approximately 6 miles northeast of Shaw, Mississippi. The second section, under the supervision of Eugene Coulter, is headquartered at Union City, Tennessee. The north end (approximately 30 miles) starts near Clinton, Kentucky, and proceeds south to a point near Union City, Tennessee. The south end (approximately 30 miles) starts about 9 miles southwest of Brownsville, Tennessee, and proceeds to a point near Oakland, Tennessee.



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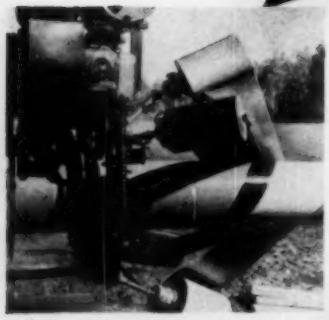

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Contractors

● **H. C. Price Company, Price Tower, Bartlesville, Oklahoma.** Has two spreads working on 335 miles of 30-in. pipeline across Arizona for *Transwestern Pipeline Company*. Spread One, supervised by G. A. "Abe" Reutzel, has commenced construction from Window Rock, Arizona, headquarters working west. Spread Two under the supervision of R. L. "Bob" Ezell begins at the California-Arizona border, working east. Headquarters for the latter spread have been established at Kingman, Arizona.

● **Rosson-Richards Company, P. O. Box 35037, Houston 35, Texas.** Has been awarded a contract by *Trunkline Gas Company* to internally clean and paint 33 miles of 30-in. pipe at Byhalia, Mississippi, under the supervision of S. O. Taylor.

● **Sharman, Allen, Gay & Taylor, Inc., 3115 Buffalo Drive, Houston, Texas.** Has been awarded a contract by *Trunkline Gas Company* to build 42 miles of 24-in. pipeline in Liberty and Hardin counties, Texas, with field office at Liberty under the supervision of E. D. Singleton.

● **Sheehan Pipe Line Construction Company, 514 National Bank of Tulsa Building, Tulsa, Oklahoma.** Has received a contract from *Transwestern Pipeline Company* to construct 300 miles of 4, 6, and 8-in. gathering lines in West Texas, Oklahoma, and New Mexico. Field office will be located at Higgins, Texas, under the supervision of J. W. Brown.

● **Stelco, Inc., 905 Barton Springs Road, Austin, Texas.** Has been awarded a contract by *El Paso Natural Gas Company* to lay an undetermined amount of various size lines in the Shamrock field under the supervision of Al Blanchard and W. K. Hancock.

● **Turriff-Burden, Ltd., (subs. Burden International, Ltd., Box 5216, Tulsa, Oklahoma).** Has been awarded a contract by the *Iraq Petroleum Company, Ltd.*, for the construction of 315 miles of 30 and 32-in. pipeline from Kirkuk to the Syrian border and connecting Rumaila and Fao. The project office in London, England, will be managed by W. T. Barker. Field construction superintendent is John H. Miller; assistant superintendent is Arnold Smith; and manager of the field office in Baiji, Iraq, is G. E. Suagee.

● **Western Pipe Line, Inc., P. O. Box 1076, Austin, Texas.** Has been awarded a contract by *Transwestern Pipeline Company* to construct 100 miles of 10, 12, and 16-in. laterals in the West Texas-New Mexico area. Field office is in Monahans, Texas; Clint Schell is superintendent; and C. L. Siewert is general superintendent.

● **Williams Brothers Company, National Bank of Tulsa Bldg., Tulsa, Oklahoma.** Has been awarded a contract by the *National Iranian Oil Company* to construct a 240-mile, 8-in. petroleum products line in Iran from Rey, near Tehran, northeast to Sharud. Has been awarded a contract by *Transcontinental Gas Pipe Line Corporation* to build 23 miles of 30-in. pipeline near DeQuincy, Louisiana, where field office will be located, with Earl Saulsman as superintendent.

PIPELINE PERSONALS

J. A. Horner, formerly secretary of the Shell Oil Company in New York, has assumed the presidency of Shell Pipe Line Corporation succeeding **Joe T. Dickerson** who has retired after 33 years of service with the Shell companies. Horner joined Shell at Tulsa in 1936 in the legal department and was a member of the group that planned the company's post-war organization and expansion. He has also served as administrative assistant in the office of the Shell Oil Company president and was assistant secretary before being named secretary in 1953. He also has been serving as vice president of Shell Development Company and secretary of Shell Chemical Corporation, International Lubricant Corporation, and Shell Canadian Exploration Company.

J. A. Horner

Norman T. Shideler, who has been manager of protective coating research for Pittsburgh Coke and Chemical Company, resigned effective January 1 to become a "coatings advisor." His new address is 4 Swan Drive, Pittsburgh 37, Pennsylvania.

J. B. Lawson, a vice president of Great Lakes Pipe Line Company for the past ten years, has retired.

J. W. Carneal has been appointed executive assistant to the vice president in charge of employee relations and land and lease for Texas Gas Transmission Corporation and will retain his responsibilities as director of sales and industrial development. He has also served the company as a soil technologist in the pipeline department, chief soil conservationist, manager of company housing, assistant superintendent of the pipeline department, industrial representative, and assistant director of sales and customer relations.

Fred Armstrong, assistant chief engineer of Plantation Pipe Line Company, has retired. Armstrong joined Plantation as an electrical foreman in 1942 when initial construction started on the pipeline system and supervised the original installation of most of the electrical equipment in the company's western division. He also assisted in designing and supervising electrical installations during the company's 1950-52 and 1956 expansion programs, and has been active in its stepped-up corrosion control program.

Glenn P. Thompson, Tennessee Gas Pipeline Company, has been elected 1960 president of Gulf States chapter No. 8, American Right of Way Association; and new vice presidents include: **Dan Williamson,** Transcontinental Gas Pipe Line Corporation; **J. M. DeBardeleben,** Bureau of Public Roads; **Kenneth E. Moreland,** El Paso Natural Gas Company; **T. E. O'Neill,** Shell Pipe Line Corporation; and **L. V. Dennis,** Interstate Oil Pipe Line Company. **William H. Huffman,** Humble Pipe Line Company, was elected secretary; and **C. E. Patton,** Houston Lighting and Power, treasurer.

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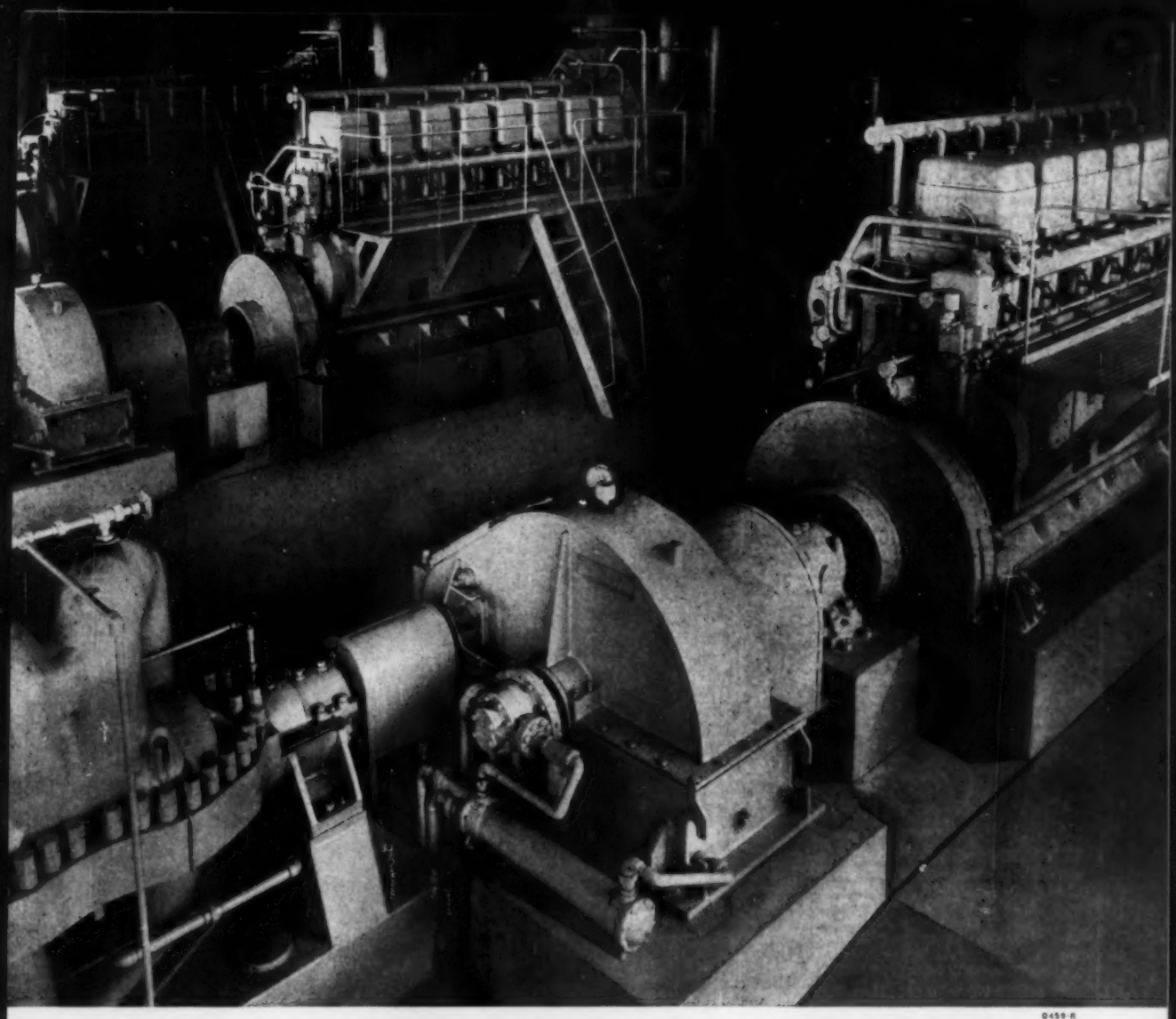

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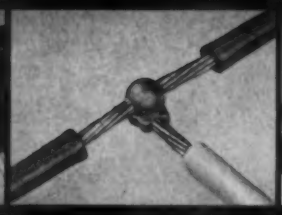

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Personals

Gardiner Symonds, board chairman and president of Tennessee Gas Transmission Company, has been elected national chairman of 1960 Invest-in-America Week, to be observed April 24-30.

George S. Patterson, president, The Buckeye Pipe Line Company, announces that **John H. Osborne** has been appointed assistant to the vice president at Macungie, Pennsylvania, and that **Charles Oleksa** has been appointed chief dispatcher, eastern products division, to replace Osborne.

Edward C. Ekola, communications engineer, has been named El Paso Natural Gas Company's new communications superintendent. He joined the company in 1947.

Earl E. Mayo, vice president of Southern Pacific Pipe Lines, Inc., has retired after 53 years' service with the railroad and its pipeline affiliate. Mayo has been in charge of many of Southern Pacific's major construction projects. He became chief engineer of the railroad's Pacific Lines in 1944 and was appointed to his present position when SP's petroleum products pipeline company was organized in 1955. The company constructed and now operates some 1400 miles of pipelines between Los Angeles, California, and El Paso, Texas, and between Richmond, California, and Fallon, Nevada.

Arthur Kline has been elected vice chairman of the Federal Power Commission for 1960, succeeding **William R. Connole.**

Harold C. Price, Sr., has been elected chairman of the board of H. C. Price Company, to be succeeded as president by **Harold C. Price, Jr.,** who began his career with the company in 1950 as timekeeper on a pipeline spread and has since served as administrative manager of the

H. C. Price, Jr.

R. K. Shivel

pipeline department, vice president, and executive vice president. Elected vice president is **R. K. Shivel,** who has participated in pipeline projects for Price company throughout the United States, South America, Canada, and Alaska and was most recently general superintendent of the pipeline division.

R. V. Lynam, veteran Tidewater Oil Company pipeline employee in the San Joaquin Valley, has retired after 41 years of service. Lynam has been first engineer at pipeline pump stations at Arbios, Silaxo, and most recently at Brito near Dos Palos, California.

J. G. Yoder, assistant purchasing agent for Great Lakes Pipe Line Company since 1947, has been promoted to purchasing agent succeeding **H. F. Swindle** who has retired after serving in that position since the company was organized in 1930.

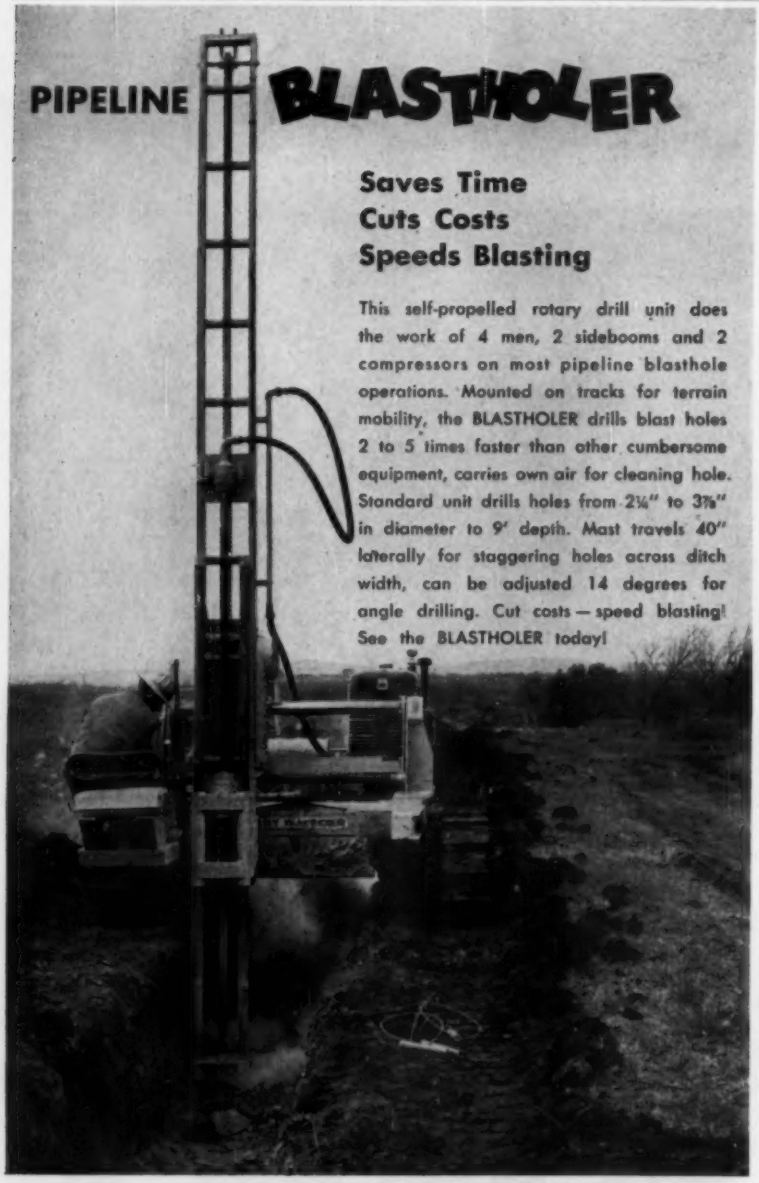
H. G. Mariner, Service Pipe Line Company general manager, announces the appointment of seven employees to key supervisory and clerical positions on the 300-mile Bayou products pipeline, the operation of which has been transferred from Shell Pipe Line Corporation to Service. They are: **Lonnie L. Collins,** terminal foreman at Baton Rouge, Louisiana; **Julius Hawkins,** station foreman at Port Neches, Texas, terminal; **Hal McClintock,** mechanic foreman at the Neches terminal; **Clark B. McCune,** station foreman at the Baytown terminal; **Eugene B. McLemore,** office supervisor at the Baytown headquarters; **James D. Parkerson,** supervisor of two Bayou stations in Buhler and Basile, Louisiana; and **Waldo W. Dean,** senior clerk-dispatcher in Baytown.

B. H. Powers, supervisor of lines for Great Lakes Pipe Line Company's southern area, has been named assistant southern area superintendent, and is being succeeded in his former position by **G. L. Pogson,** formerly assistant to the area superintendent.

Gordon Flack, Platte Pipe Line Company, has been promoted from junior engineer to engineer. His responsibilities include work in the mechanical, structural, and hydraulic functions in the engineering section.

J. Clifton Williams, Jr., a senior assistant engineer with Texas Eastern Transmission Corporation in Shreveport, Louisiana, has been named division engineer of the company's Division I, North Little Rock, Arkansas.

Claude A. Lamb, district foreman in charge of maintenance and construction for Tidewater Oil Company pipeline facilities in the Los Angeles Basin area, has retired after 36 years with the company.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Personals

Paul F. McBride has been named operations manager of Transwestern Pipeline Company, one of four key appointments marking the company's first steps in acquiring its personnel requirements by the time the line is ready for operation in mid-1960. **William A. Koros** was appointed controller and assistant treasurer and secretary; **Ben A. Copass, Jr.,** manager of gas purchase contracts; and **Leslie M. Fisher,** superintendent of the Puckett gas purification plant at Fort Stockton. McBride has served with United Gas Pipe Line Company, Algonquin Gas Transmission Company, Fish Northwest Constructors, Inc., and prior to his appointment was general superintendent of operations for Pacific Northwest Pipeline Corporation. Koros has been serving as assistant to the vice president, rate department, of the Charleston Group Companies of the Columbia Gas System. Copass has been employed by Humble Oil and Refining Company since 1947. Fisher was previously plant superintendent of the Carthage Corporation processing plant and assistant district superintendent.

George Beck, senior staff engineer for Continental Pipe Line Company, Ponca City, Oklahoma, has joined the staff of Williams Brothers Company, Tulsa, pipeline contractors, as a senior engineer.

Richard J. Emerson, formerly corrosion engineer in El Paso Natural Gas Company's electrolysis and communications department, has joined the engineering department as chief corrosion engineer. Emerson has been with the company since 1946.

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Burndy Export Manager

Appointment of William E. Lett to the newly created post of export sales manager of Burndy Corporation's utility-industrial division has been announced by Eric E. DeMarsh, vice president and U-I division general manager. Lett will be responsible for the development of export outlets, both domestically and in Latin American countries for the manufacturer of electrical connectors.

Previous positions held by Lett include: export sales manager of Noranda Copper and Brass, Ltd.; salesman for the agricultural chemical division of Industrias Quimicas Uruguayas "Duperial" and manager of its sundries products division; and assistant advertising manager of Compania Massey-Harris Ltda., in Argentina.

W. E. Lett

Assignment In Coatings

Robert Gilliland has been appointed sales engineer for the Reilly Tar & Chemical Corporation, according to announcement of J. H. Barnett, Jr., sales manager. Gilliland will be attached to the Houston, Texas, sales office as a representative in the coal-tar enamel pipeline coating division.

R. Gilliland

Ransome Name Re-Emerges

Re-emergence of the 110-year-old name, Ransome, pioneer in the concept and manufacture of welding positioning equipment, has been recently announced by Paul Galton, general manager of the new Ransome Company, at the firm's new general offices in Scotch Plains, New Jersey.

The Ransome Company, now a wholly-owned division of the Big Three Welding Equipment Company, recently acquired the complete welding positioner business of the Worthington Corporation, which, in 1943, purchased the Ransome Machinery Company and incorporated it into its Worthington-Ransome division.

It is the Ransome Company aim to continue the manufacture of the standard line of welding positioners, turning rolls and welding head manipulators and, at the same time, to enter fully into the field of machine tools for automation welding. Ransome manufacturing operations are being continued at the Worthington Plainfield division while a new Ransome manufacturing facility is underway.

Galton, who headed the former positioning equipment division of the Worthington Corporation, has 19 years' experience in the welding industry.

Expands Into Line Pipe

Expansion of Dunwoody Pipe & Supply Company into line pipe sales and the appointment of veteran Houston pipeliner, E. Cary Link, Jr., as line pipe sales manager has been announced by L. Ray Dunwoody, president of the Houston-based firm.

Link began his pipelining experience with War Emergency Pipeline, Inc., was employed by Tennessee Gas Transmission Company during the laying of their initial lines, was superintendent of gas control for Transcontinental Gas Pipe Line Corporation, was in charge of traffic and material control for Fish Constructors during the building of the Transco system and Pacific Northwest Pipeline, and immediately prior to joining the Dunwoody company was vice president for Jess Edwards, Inc., pipeline hauling and stringing company.

Purchases Maxi Carrier

Crane Carrier Industries, Inc., of Tulsa, Oklahoma, has purchased the Maxi division of Insley Manufacturing Corporation, Los Angeles producer of self-propelled carrier vehicles designed for operation from the crane or shovel mounting.

The Los Angeles plant is being dismantled for reassembling in Tulsa where production on the Maxi model has already started at the Crane Carrier twin-production lines. The Maxi carrier differs from the Crane carrier in that one man operates the Maxi shovel and truck from the same seat.

Where's the Fire?

There isn't any. This spread is using the new CORR-PREV Pipe Coating Team — CHASEKOTE and CHASEWRAP. Pipe is wrapped cold, right from the roll. No fires, fumes, heating or drying time. CORR-PREV high-speed cleaning and wrapping machines apply CHASEKOTE and CHASEWRAP to the pipe in *one* continuous operation. The result: Smaller, faster moving coating crews . . . more footage per day . . . *plus* unequalled under-ground pipe protection at *lowest applied cost!*

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— is an abrasion-resistant, wrinkle-free overwrap that effectively shields against backfill and soil stress damage. Wraps simultaneously with tape. Superior to rag and felt wraps, yet *lower* in cost.

*Trade name of Chase & Sons, Inc., long-famous for protective and insulating tapes for electrical wire and cable.

The New CORR-PREV Pipe Coating Team

Try this new CORR-PREV Pipe Coating Team on your next job. You get all coating items — including high-speed wrapping machinery — from one dependable source. Each roll of CHASEKOTE and CHASEWRAP is factory-uniform in quality and thickness, to give you longer-lasting protection — *and save you money* — every time you place pipe underground! **CHASE & SONS, INC., 26 Spruce Street, North Quincy, Mass.**

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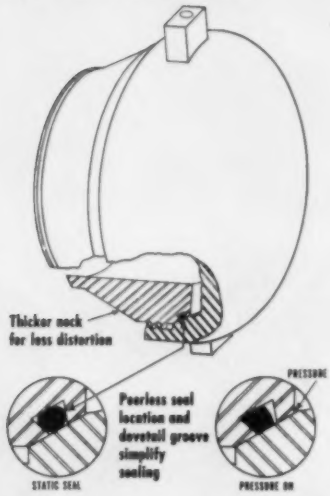
New "O" Ring Closure



A new, simplified "O" ring closure, while incorporating an "O" ring seal to achieve bubble tight seals regardless of fluid pressure, has a new feature — location of the seal on the outer edge and dovetail groove which make it easier to insert the "O" ring and to hold it in place. The seal is positioned away from possible sealing surface damage. Thickness of the neck makes it less subject to distortion. Cap hinge is an integral part of the closure. Opening device insures one-man operation. It is available in a full range of sizes, and installation requires only the welding of the closure weld neck with a circumferential weld. *Sillers Engineering Co., div. of Peerless Mfg. Co.*

Circle number (81) on reply card.

"Split Channel" Frequency Checks

A new system called the PPM package, developed with the collaboration of the national service unit, General Electric communications department, measures the frequencies of mobile-radio transmitters to the FCC split-channel tolerance of 0.0005 percent (above 50 mc). It consists of the Lampkin micrometer frequency meter and a Measurements Corporation Model 111 crystal calibrator modified by Lampkin to include a 3½-in. diam dial, which tunes the crystal and is calibrated in parts per million, with a range from plus 25 ppm to minus 25 ppm. When used in conjunction with WWV receiver, transmitter-frequency checks can be made to an accuracy of better than one part per million. *Lampkin Laboratories, Inc.*

Circle number (82) on reply card.

New Saddle Design

A new full-encirclement saddle—with 2 additional splits each 90 deg from the nozzle, in addition to the essential split through the nozzle — can be installed on existing lines without excavating the usual bell hole and without requiring bottom weld. All welding is from the top and sides. *Steel Forgings, Inc.*

Circle number (83) on reply card.

Speed-Indicating Device

A new speed-indicating instrument that requires no mechanical connection between it and the rotating shaft has been introduced for use with small steam or gas turbines. An electromagnetic pickup senses the speed. The signal is applied to an all-static circuit, which transforms the pulses from the pickup to a d-c mv signal. The output signal magnitude is proportional to pulse frequency. *Westinghouse Electric Corp.*

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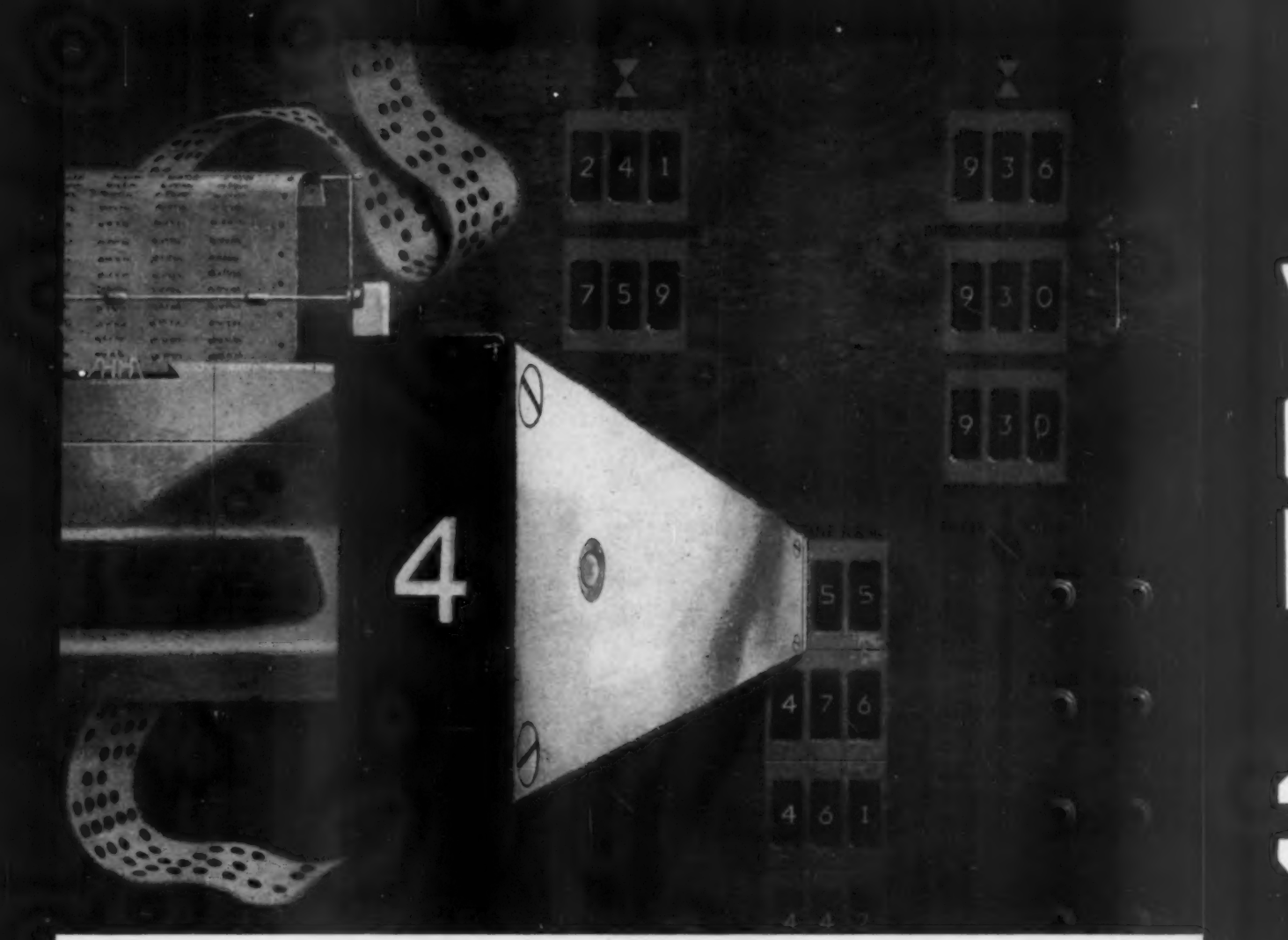

NEW CONTROL CONCEPT
can cut your pipeline costs

Did you ever try to solve a jigsaw puzzle without first looking at the total picture the puzzle makes? Pretty difficult—maybe even impossible. Best way, easiest way is to look at the big picture first, then see where the individual pieces fit.

It's the same with pipeline control.

First, look at your total system problem. Then, determine what sort of control system is required to safely, reliably and economically meet tomorrow's need as well as today's. That is Union Switch & Signal's approach to pipeline control.

Any part of a pipeline system. Union Switch & Signal can incorporate in a centralized control system any or all of the following functions: supervisory or remote control of satellite stations . . . telemetering of flow data from field back to your central dispatching office . . . automatic sequencing or control of equipment in the field . . . instrumentation . . . data handling and display . . . computing equipment . . . automatic integration of field data into your accounting operations . . . communications. Union Centralized Transport Control can be adapted to *any* problem from remote control of a single-unit booster station for gas or oil to automatic centralized control of an entire system from wellhead to ultimate consumer.

Error-free. Whatever the job assigned to it, Union Centralized Control operates completely free from error because it reduces to coded digital form all information and instructions transmitted to or from your central control office. As a result, you can transmit far more precise data than ever before; you can use the least expensive available communications service; and you never need to worry about lightning, noise or other interference causing a wrong or dangerous operation—this coded system automatically checks itself and responds *only* to correct and logical signals. It helps make your pipeline safer. It provides error-free *security* as well as reliability.

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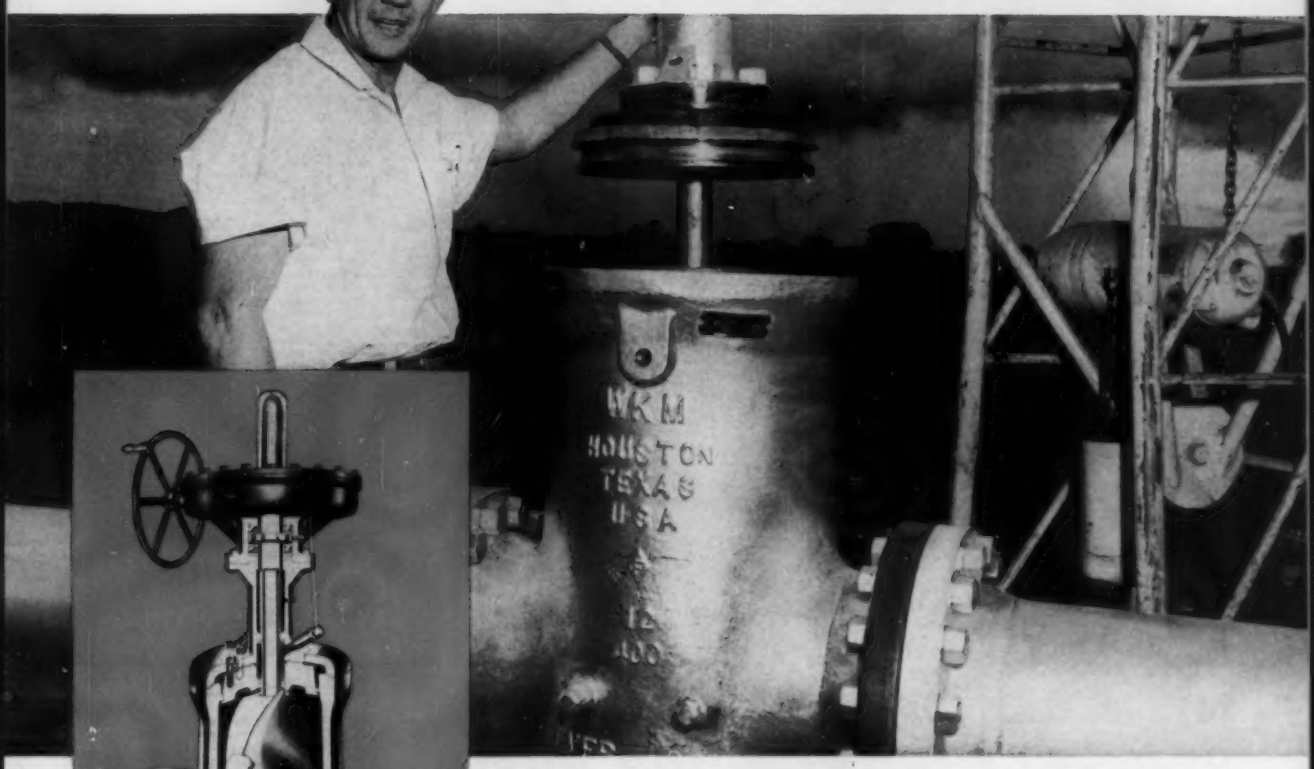

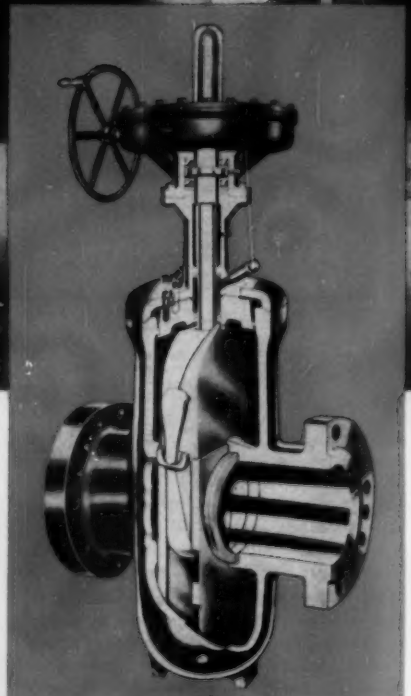

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Greater efficiency for planned or existing systems

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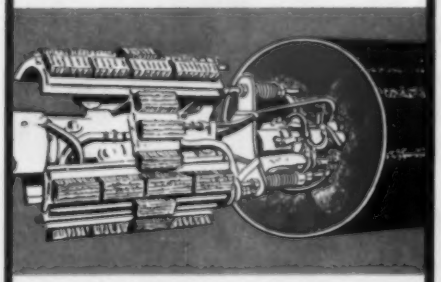
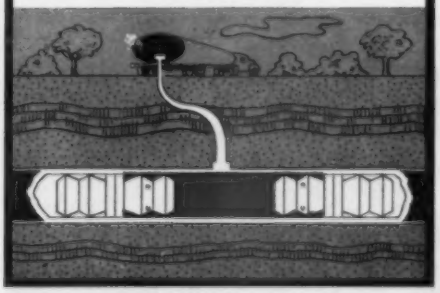


PIPE IN GROUND



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Exclusive dual-range Hydra-Crowd transmission makes the big difference, enabling your operator to dial *instantly* the maximum crowding speed for any ground condition, or reverse *instantly*, too. He selects from *infinitely variable* crowding speeds *independent* of wheel and conveyor drive. No four-operation gear shifting. No guessing about gear ranges. No stopping to change speeds.

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- All-hydraulic spoil conveyor independent of wheel speeds for instant selection of infinitely variable speeds—instant reverse.
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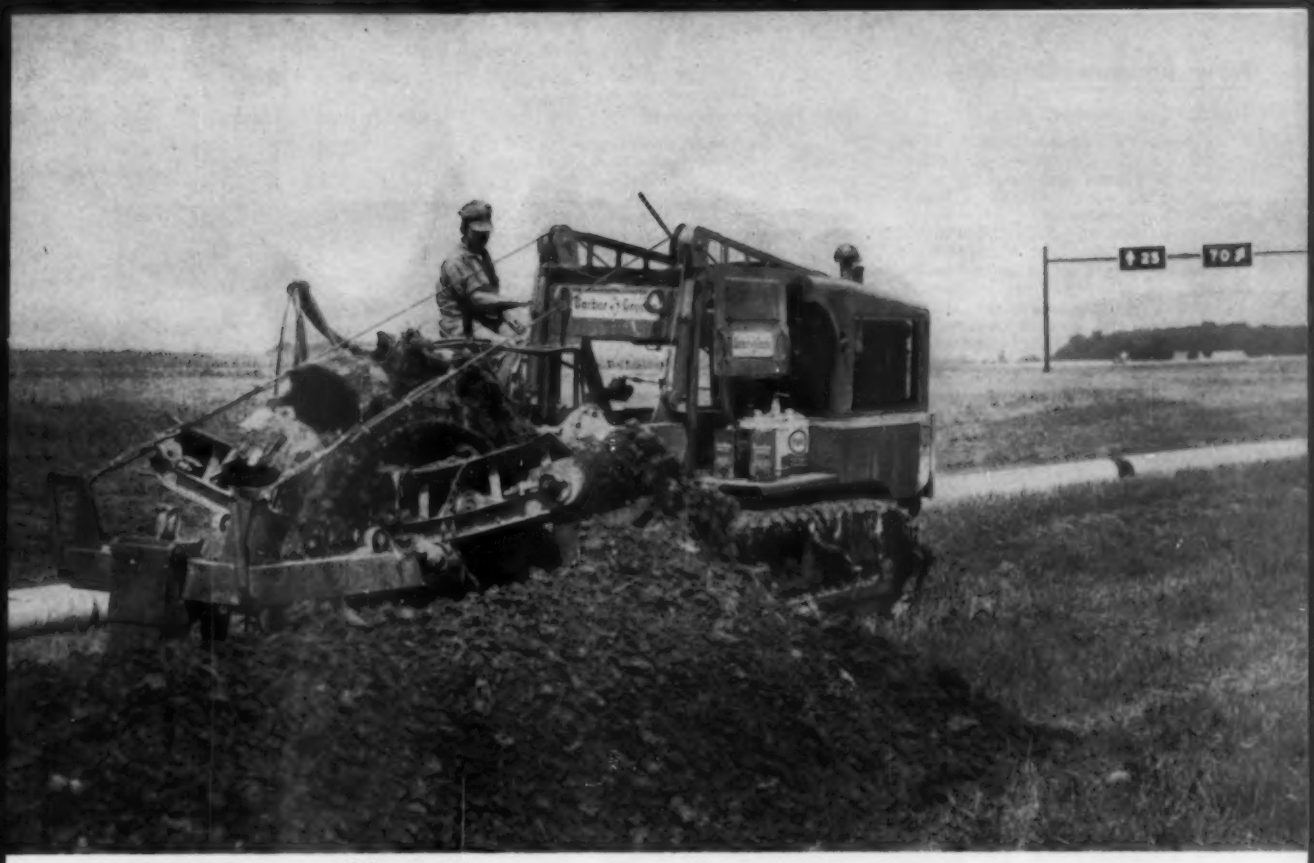

Model 774 shown with standard 5'6" depth, 30" width wheel. Optional model digs to 7' depth.

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MODEL 774—INDUSTRY'S BIGGEST BUY FOR DIGGING 7-FT. DITCH

The new Barber-Greene Model 774 Wheel Ditcher can be equipped with a 7-ft. wheel with complete options and accessories for 50% less than you pay for any other wheel ditcher that can dig this depth. Call for prices and be convinced.

Crawler, rubber-tired Barber-Greene Vertical Boom Ditchers cut low costs trench from 5½ to 24-in. wide and to 7 ft. deep. Model 784 is shown.

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New Equipment

Turbo Conversion Kits

To increase horsepower from 32 to 50 percent on its RA series gas-engine-driven compressors and from 20 to 36 percent on the HRA series, Clark Brothers Company, one of the Dresser Industries, has introduced complete field turbocharging conversion kits. Each package includes not only a jet air started turbocharger, but scavenging air intercooler, dry exhaust manifold, control mechanisms and all other parts required for a dependable, turbocharged engine. Because of more efficient operation and the elimination of a water cooled exhaust manifold, cooling duty remains almost constant, even though horsepower is increased as much as 50 percent. *Clark Bros. Co.*

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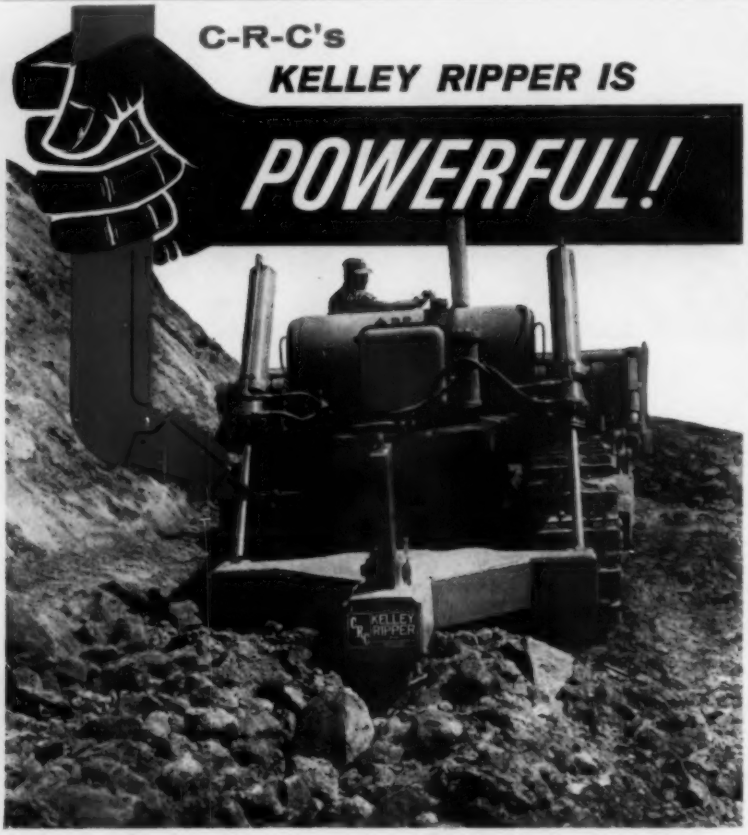
Big Tractor Shovel

A new four-wheel drive tractor shovel has a carry capacity of 9000 lb, breakout capacity of 23,500 lb, and standard loader bucket SAE-rated at 2½ cu yd. Designed around a Case 120-hp diesel engine, the new W-12 Terraload'r also features: torque converter drive that automatically and instantaneously more than triples engine output torque to meet increasing loads; constant mesh transmission providing speeds from 0 to 23 mph in either direction through three speed ranges; power transfer differential for all four drive wheels; and power shift, steer, and brakes. Control is hydraulic, and use of large pumps provides 7½ sec lift and 4½ sec dump. *J. I. Case Co.*

Circle number (86) on reply card.



- Powerful enough to rip seven feet deep through rock, frozen ground, and hard-packed earth.
- Powerful enough to completely eliminate expensive ditch shooting in many cases.

The Kelley Ripper is available through your Caterpillar dealer. Or, write C-R-C for complete details.

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"Unit-Option" Trucks

Three new off-highway trucks for construction have been introduced — White Model 4400D-OH, diesel powered, with 26,000-lb capacity single rear axle; and the 26,000-lb capacity single-axle model 4200-OH and 44,000-lb capacity tandem-axle 9064-OH, driven by White Mustang gas engines. Standard front axle on all three has 15,000-lb capacity. There are optional rear axles for all three. Especially engineered to the exact requirements of each operator under White's "unit-option plan," the new models have double-channel frame of heat-treated chrome manganese steel with bolt and nut construction instead of rivets, and all three models have five-speed main transmissions with varying options. *The White Motor Co.*

Circle number (87) on reply card.

Activates Desired Unit In 2-Way Radio Network

Enabling a radio dispatcher to alert and talk to individual mobile units in his network without bothering other vehicle operators is the new transistorized "Quik Call" selective signaling decoder for use with Motorola mobile two-way radios, including the recently developed transistorized Motrac. The dispatcher presses a button on his control console to activate and transmit a pre-set series of tone signals which are received by all mobile units and fed to decoders. The decoder in the desired mobile activates its receiver's audio circuitry. The decoder can be connected to the truck horn or a light to signal a driver who is away from his vehicle. *Communications and Industrial Electronics Div., Motorola, Inc.*

Circle number (88) on reply card.

Tractor for Light Work

A new four wheel drive tractor especially designed for light construction work is announced in four different, hydraulically operated and ready equipped models — bulldozer, grader clam, roll bucket, and loader. These 2000-lb units feature: new controlled differential steering to give a turning radius of 12 in. . . . in a 6-ft curb-to-curb circle; double-acting hydraulic cylinder with float position valve; and design that allows easy removal of clutch or transmission. The operator is seated forward for visibility and better operating balance. *Detroit Tractor, Ltd.*

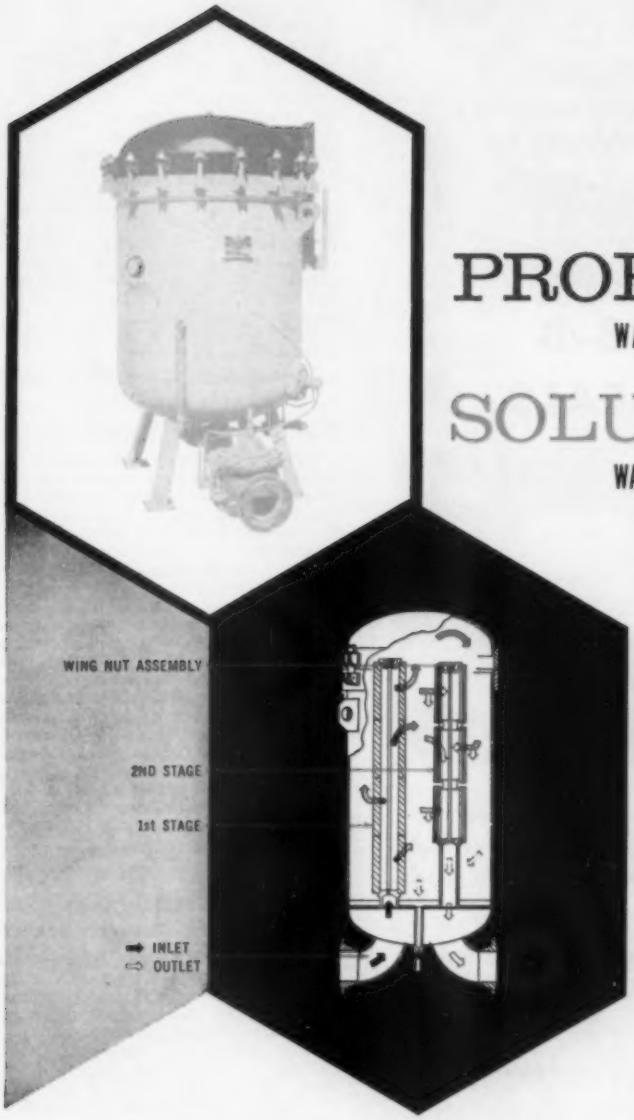
Circle number (89) on reply card.

Motor Protection Relay

A new relay provides motor protection by combining several elements to more closely match the motor heating curve. From minimum pickup to 175 percent of tap value setting, an alarm is sounded and an operator is allowed five to ten minutes to remove the trouble. With medium overloads, the COM-5 gives normal time delay tripping protection. The relay provides for instantaneous tripping on heavy fault current. *Westinghouse Electric Corp.*

Circle number (90) on reply card.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD



PROBLEM:

WATER AND DIRT IN PETROLEUM PRODUCTS

SOLUTION:

WARNER LEWIS TWO STAGE SEPARATOR/FILTERS

For Process, Pipeline and Marketing Facilities

HOW IT WORKS

Coalescing-Filtering
Hydrocarbon and water enter inlet and pass through the coalescer cartridges where solids such as dirt, rust and scale are removed and mechanical emulsions are broken. Finely dispersed water droplets gather together into large water droplets and fall by gravity into the water-collecting sump.

Separating
Clean hydrocarbon and any entrained water droplets flow to the separator cartridges. This chemically-treated media completely blocks the passage of water and clean hydrocarbon passes through the cartridges to the outlet.

Two stage design provides positive protection against contaminated products not possible in single stage designs.

Replacement cartridges feature high dirt holding capacity and low cost replacement.

Write Process Section, Warner Lewis Company, for details.

WARNER LEWIS COMPANY
BOX 3096 • TULSA, OKLAHOMA

DIVISION OF FRAM CORPORATION

TESTED IN OPEN COMPETITION

. . . and ANOTHER Pipe Line Company CONVERTS TO John Crane® 8-B SEALS

A COMPETITIVE FIELD TEST in which one half the pumps were equipped with JOHN CRANE 8-B Seals and the other half with various competitive seals was recently conducted by a leading pipe line company.

THE RESULT showed that in *every* case the JOHN CRANE 8-B Seals out-performed all other seals in the system both in positive sealing and length of service.

PROOF AGAIN that wherever service is tough and pressures are high, 8-B Seals successfully do the job.

JOHN CRANE 8-B Seals are easily installed and will handle all pressures encountered in modern pipe lines. They are available in a full range of shaft sizes for every main line or tank farm pump service.

Request Bulletin S-215-1. Give mechanical and service details for specific recommendations.

•

Crane Packing Company, 6486 Oakton Street, Morton Grove, Illinois (Chicago Suburb)

In Canada: Crane Packing Company, Ltd., Hamilton, Ont.

CRANE PACKING COMPANY

New Equipment

Mobile Radio to Use Standardized Connector

For vehicular applications — and easily adaptable to both dash and trunk installations — is a new, easy-to-service two-way radio that uses transistors and printed circuits extensively. The power supply is completely transistorized and there are only two tubes in the receiver . . . retained to give it its 0.4 mv sensitivity. Beginning with this "2V" series, the manufacturer, Bendix, is pioneering a program of standardized connectors, in which the 2V and all subsequent Bendix two-way radio units will use the same type of connector to spare fleet operators the expense and annoyance of modifying installations for each new type of communications unit. Also being introduced along with the new unit are matching 9LS speaker and 7CA control unit. *Bendix Radio Div., Bendix Aviation Corp.*

Circle number (91) on reply card.

Alarm/Control System

Designed primarily for pipeline and similar companies that monitor and control unattended locations remotely from a central control point is a new alarm/control system which may be used with various types of transmission media. The control signals employed are in the form of tones. They may be used to check a single location or as many as 100 different points. Ten functions may be checked at each point. A small console, desk-mounted at the control terminal with cable connecting with rack-mounted tone equipment, has a bank of indicator lamps to show stations being selected and a second bank to show whether any faults are present. A dial is used to select and check desired station and to operate remotely-controlled equipment at unattended distant points. *Communication Products Dept., General Electric Co.*

Circle number (92) on reply card.

New Tooth Penetration With Backhoe Attachment

A new patented positive pressure backhoe attachment for all sizes of American Hoist backhoes enables the operator to use almost the entire weight of the machine when digging through rock or the hardest ground. A one-way hydraulic cylinder is fastened at the top of the mast. The cylinder piston is secured to the backhoe boom, forward of the boom seat. The unit contains an oil reservoir, a flexible hydraulic line from the reservoir to a valve and then on to the cylinder. Its operation is automatic. As soon as the operator starts his inhaul, the hoist line goes slack, which actuates the hydraulic valve, locking the oil in the cylinder. This action makes the cylinder act as a solid connection between boom and mast or back stay. *American Hoist & Derrick Co.*

Circle number (93) on reply card.

For Materials Handling

Called the efficient answer to close quarter load-handling problems is the "Tug-Bar," a motorized pry bar. It weighs only 110 lb, is electrically powered, and operated by one man. One man, equipped with a Tug-Bar, can easily position a piece of machinery weighing four tons, according to the manufacturer. *Western Gear Corp.*

Circle number (94) on reply card.

For Big Construction

Two new big capacity, air operated shovel cranes are designed to permit knock down for job-to-job transportation. As a standard shovel, the Lima Type 1800 is equipped with a 35-ft boom, 26-ft-10-in. dipper handle, and 5 cu yd dipper, as a crane it has a lifting capacity of 112 tons, and dragline capacity is variable. The Type 1800SC is a 140-ton capacity crane with extra wide trunk base width. Each side frame assembly, including belts, crawler chains, and sprockets, is removable as a unit. Counterweight segments are also removable and the backhitch-telescopic-type gantry can be folded to a height of 17 ft, 5 in. Both are available with diesel or electric power with torque converter drive. *Baldwin-Lima-Hamilton Corp.*

Circle number (95) on reply card.

Compact Valve Offered

A new, simple, compact valve for general pipeline and manifolding service is announced in sizes from 2 to 36 in. The G-5, available in a quick-opening lever operated model and a hand wheel operated model that is equipped with double acme threads for fast action, provides a seal on the upstream and downstream sides of the gate, offers a reduction in hook-up costs for block and bleed service by eliminating one valve and a spool previously required in such assemblies, and has metal seat rings that are in constant contact with chrome plated body side plates for continuous scraping action through all gate positions. When in open position, the G-5's "O" ring is completely removed from flow preventing damage from foreign matter in the flow line. *Grove Valve and Regulator Co.*

Circle number (96) on reply card.

Simplified 2-Way Radio

A new two-way mobile radio, the Transicom, uses transistors, other semi-conductors, and vacuum tubes together with simplified circuitry to achieve low-cost, maintenance-free service. This Type MCA 325 transmitter/receiver, compact for mounting under a vehicle dashboard, operates on the 144-174 mc band with transmitter powers of 10, 20, and 30 w. A 50-w unit for use on 25-54 mc frequencies also will be produced by the manufacturer. Incorporated in the small 12-in. deep mobile radio is an integrated 3-in. by 5-in. speaker at the front panel with sound directed at the driver-operator's ear. *Allen B. Du Mont Laboratories, Inc.*

Circle number (97) on reply card.

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1959 Annual Index.

Write The Petroleum Engineer,

Box 1589

Dallas 21, Texas

Scraper Passage Indicator

PIG-SIG II is a new scraper passage indicator that operates on the same principle as the original PIG-SIG developed by T. D. Williamson, Inc. The trigger which extends through the pipe wall is tripped by the scraper, thus actuating either an electrical or visual signal. The new design is more compact and can be installed and removed under line pressure. The longer trigger detects scrapers in oversize pipe or scraper traps. Operation direction may be changed under pressure. There is no packing to tighten. PIG-SIG II is said to have accurate "repeatability", suitable for metering or calibration. It can be installed with various Williamson-Hillco tapping machines using a standard drill. *T. D. Williamson, Inc.*

Circle number (98) on reply card.

New Crane, Carrier

Announced is a 65-ton Lorain Moto-Crane on an all new carrier constructed with a new welded box-section chassis frame 22 in. deep. The 230-in. wheel base provides 14 ft between second and third axles. The unit travels up to 37.6 mph and has air brakes on all eight wheels. Four "Power-Set" outriggers can be extended to working position in less than 60 sec and automatically adjust to rough terrain and level the machine. The turntable is attached to the carrier by Lorain's "Shear-Ball" connection. The machine is equipped with 40-ft square-tubular-chord boom. Because of pin-connected sections, sections may be added to give up to 170 ft of main boom. *The Thew Shovel Co.*

Circle number (99) on reply card.

Wherever there are Pipelines . . .

You'll always find

MATHEY

PIPE CUTTING & BEVELING MACHINES

Sizes 1½" to 36" in Aluminum • 4" to 36" in Cast Iron

AUTOMATIC TONGS

For safer, faster and easier pipe handling. Releases pipe automatically. Does not require anyone near tong to release it.

SPECIAL PROCESS HARDENS ALUMINUM RING GEARS TO GIVE YOU DURABILITY YOU REQUIRE, YET MAINTAINS LIGHTNESS FOR FATIGUE-FREE WORK

Mathey Pipe Cutting and Beveling Machines are quick, easy, operating, assuring clean accurate cuts. It slips over pipe with no hinges or latches and a flexible shaft or motor unit attaches easily. Mathey machines are the result of over 25 years of engineering and field research. Complete stock of units and parts available at all times. Write for illustrated catalog.

- OUT-OF-ROUND ATTACHMENTS
- COUPON CUTTERS
- SHAPE CUTTING ATTACHMENTS
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First & Oldest Manufacturers of Saddle-Type Pipe Cutting & Beveling Machines
Available through your favorite supplier

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It's New | Pipeline Literature

For Field Gathering

A small horsepower, heavy-duty integral engine-driven compressor specifically designed for gas field gathering service — the DM-125, manufactured by Cooper-Bessemer and skidded, prepiped, and given a closed water system by C-B Southern, Inc. — is the subject of a new 6-page bulletin. It describes the power unit and compressor cylinders used in the packaged construction. *The Cooper-Bessemer Corp.*

Circle number (100) on reply card.

Engine Folder

A new engine folder presents 24 models, from stripped engines to complete power units. In "International Engines and Power Units," 10 of the engines are diesel units, with four or six cylinders, while 14 are of the four, six and V-eight-carbureted variety. *Construction Equipment Div., International Harvester Co.*

Circle number (101) on reply card.

Presenting Pipelayers

Brief specifications and such features as increased horsepower, dry-type air cleaner, and "lifetime lubricated" rollers are included in a new, 2-color booklet, "Presenting the Caterpillar No. 572 Series D and MD7 Pipelayers." *Caterpillar Tractor Co.*

Circle number (102) on reply card.

Use of Leak Detectors

Detailed instructions on the use of halogen leak detectors for finding leaks in enclosures that can be pressurized are given in the 6-page bulletin "Leak Testing of Tanks, Piping and other Enclosures." System preparation, testing procedures, quantitative measurement techniques, and calibration are discussed. *General Electric Co.*

Circle number (103) on reply card.

Electric Power Drives

An electric power drive catalog, revised and expanded to 68 pages, includes over 8000 ratings; data on the new "Sterlicone Multi-Shielded" line of drip-proof motors; and dimensions and modifications for squirrel cage motors, gearmotors, speed reducers, right angle gearmotors, right angle variable speed drives, and variable speed drives. *Sterling Electric Motors.*

Circle number (104) on reply card.

Butterfly Valve Data

Iron body, rubber seated butterfly valves manufactured by Darling under license from the Pelton Division of Baldwin-Lima-Hamilton Corporation are the subject of a comprehensive, 36-page catalog that includes data on construction and design, dimensions, general hydraulic data, materials, and methods of operation. *Darling Valve & Mfg. Co.*

Circle number (105) on reply card.

Pipe Cleaning Tools

A brochure is available describing a line of tools used for internally cleaning pipelines and restoring capacity even when the line is completely clogged. The brochure includes description of special rodding equipment and scale drills employed in instances where the encrustation is extremely hard or hydraulic pressure is not great enough to operate a pressure line scraper, as well as description of pressure line scrapers. *Flexible, Inc.*

Circle number (106) on reply card.

Motor Reducers

Construction and mechanical features of motor reducers in eight housing sizes for applications up to 125 hp and output speeds of 9 rpm to 420 rpm are discussed in the new catalog "Philadelphia Vertical Motoreducers and In-Line Reducers." A complete selection guide, this 28-page catalog outlines load characteristics, including horsepower and torque ratings, overhung loads, and maximum allowable thrust loads, and covers complete mounting dimensions and parts lists. *Philadelphia Gear Corp.*

Circle number (107) on reply card.

Turbocharged Compressors

A new bulletin fully describes and illustrates the crankcase, bed section, pistons, crossheads, and running gear of the turbocharged, redesigned line of Clark HRA-T gas-engine-driven compressors, with specifications and dimensions of this 14-in. by 14-in. bore and stroke machine which is built in four, five, six, and eight cylinder models with horsepowers ranging from 660 to 1320 bhp. *Clark Bros. Co., One of the Dresser Industries.*

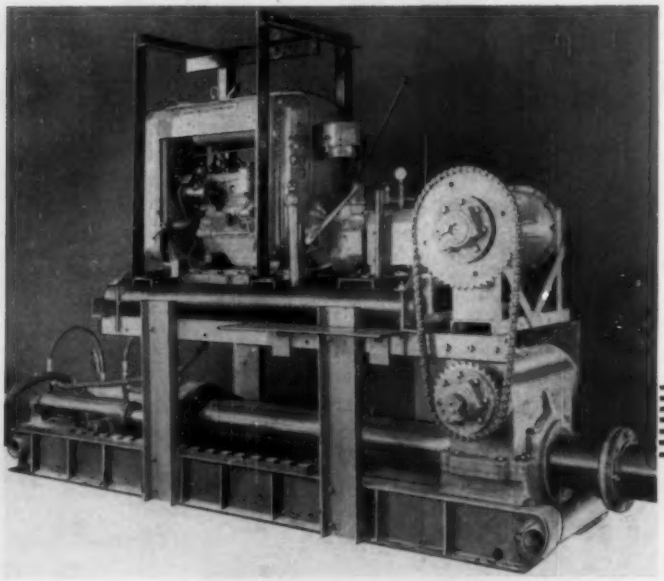
Circle number (108) on reply card.

NEW

- **EASY TO INSTALL**
- **EASY TO OPERATE**
- **EASY TO BUY OR RENT**

YOUNG *UNIFIED* UNDER ROAD . . .

PIPE LINE BORING MACHINE—*Installs casings 6" to 30" sizes*



(36" diameter in limited lengths).

- **Bores and installs casing in ONE operation — through various types of soil and rocky formations. Pipe lengths are welded on as boring progresses.**
- **Power unit, now compactly mounted on boring machine, readily removable.**
- **Saves setting up time.**
- **Eliminates costly cribbing, caving and backfilling.**
- **Operator's position now allows full visibility control for all supervisory operations.**

NOTE: Chain guard not shown in photo.

Write for Bulletin 15-PE now. Ask about our RENTAL plan.

YOUNG

ENG. CORPORATION

CANTON, OHIO

Duriron®
impressed current
Anodes
for cathodic protection of a pipe line were jetted into position in 60 seconds!

4-year-old installation WITHOUT BACKFILL provides positive protection

Creek bed . . sandy soil . . pipe line . . difficult protection problem, but not for Duriron Anodes! As shown in photo above, 20 Duriron Anodes were jetted into place WITHOUT BACKFILL using a high velocity stream of water and were placed with the top of the anodes 3 feet below the surface. *Each anode was in position within 60 seconds.*

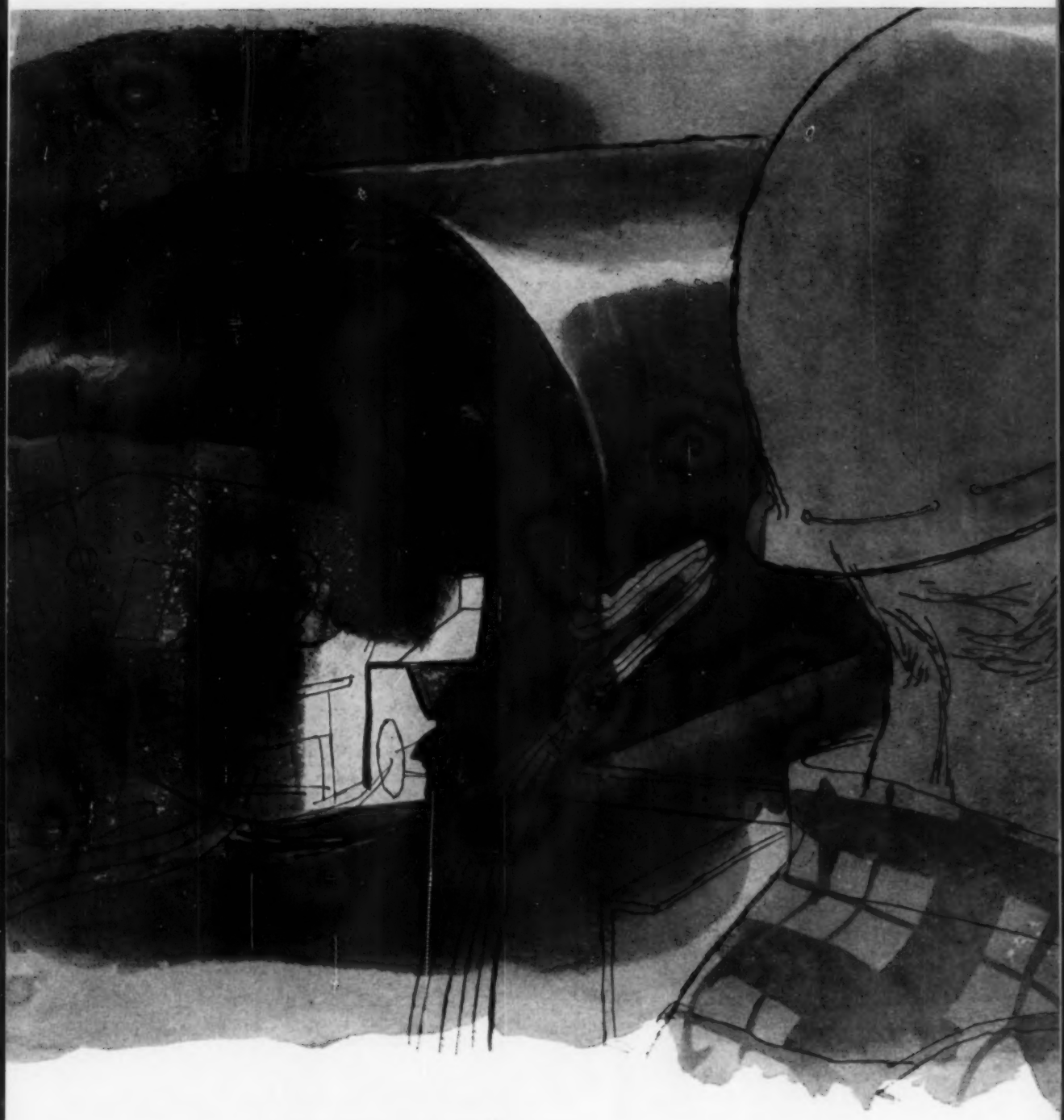
The group of anodes produced an average of 33 amps at 36 volts with no tendency to gas block. Actually, the bed resistance has decreased since the original installation. There was considerable cost-saving in the elimination of carbonaceous backfill.

For latest data and case histories on fresh water, salt water, and ground bed application, write for Bulletin DA/6.

Water jetting of Duriron Anodes has been successfully applied in clay, shale and sand.

make Duriron Anodes your guarantee for cathodic protection

THE DURIRON COMPANY, INC.
DAYTON, OHIO



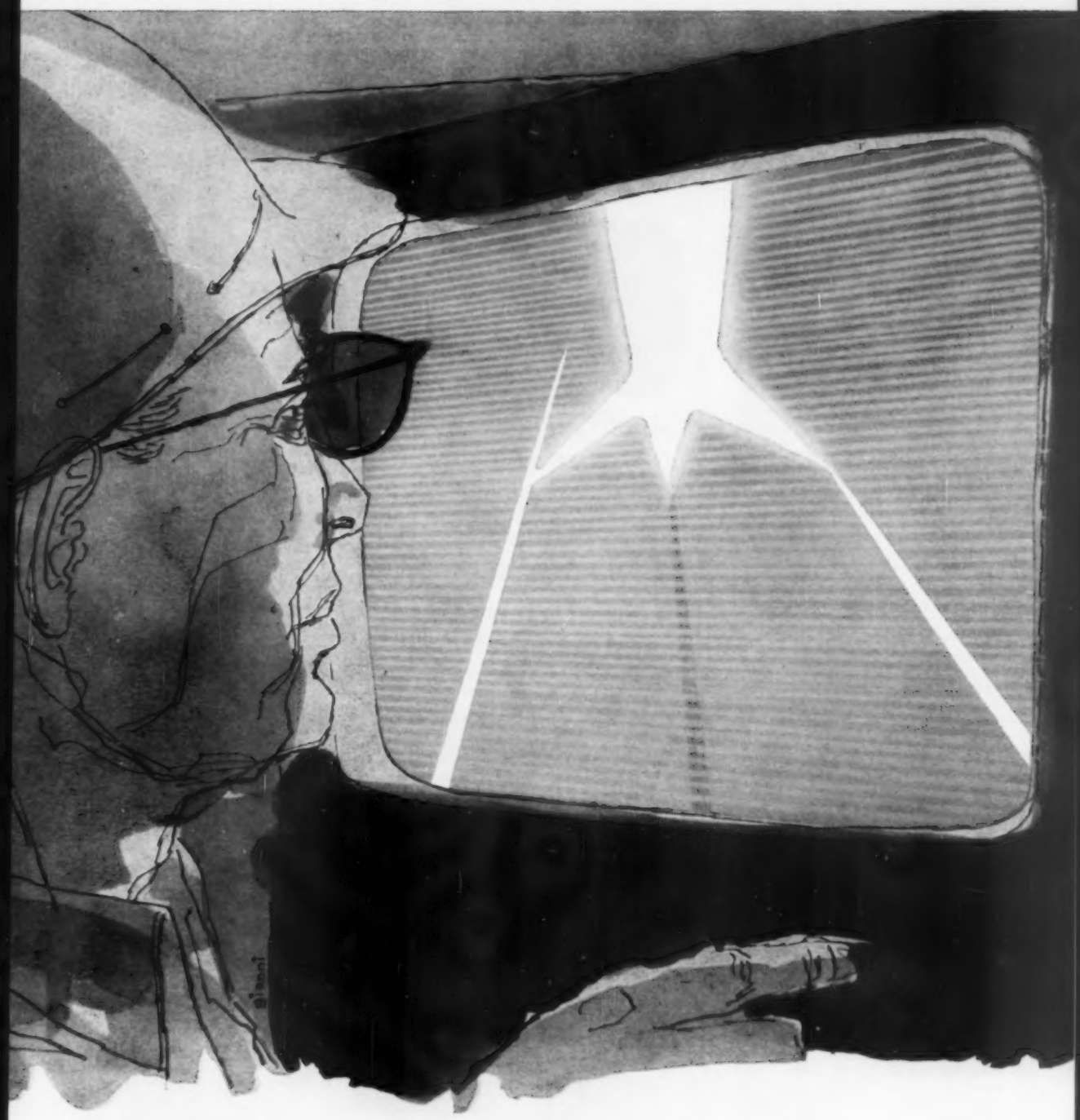
Spying on a weld

A TV camera is the spy! Located inside that hulking section of USS National Electric Weld Line Pipe, it's a visual guide to accurate welding.

The operator welds by remote control. He uses push buttons to operate a welding head inside the pipe. Just in front of the welding head is a short-focus TV camera.

When the image flashes on the TV screen, the operator sees reference lines and uses them as a guide. This enables him to keep the electrodes for the inside weld centered on the seam of the formed plate. *In short:* the TV camera makes precise guiding of the welding possible.

FOR FURTHER INFORMATION ON
ADVERTISED PRODUCTS, SEE READER SERVICE CARD



The constant development and improvement of production techniques are just two of the reasons why National Tube is not only the largest but also the most experienced manufacturer of tubular products in the world. For more information on USS National Line Pipe, write to National Tube Division, United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania. Ask for bulletin #23.

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SKINNER-SEAL

PIPE JOINT CLAMP STOPS LEAKS

at joint where pipe is screwed into fitting

SKINNER-SEAL
PIPE JOINT CLAMP stops leaks at joints where pipe is screwed into fitting. Any temperature—any pressure up to 2,000 pounds. Saves the cost of tearing out and renewing leaky fittings. Prevents shutdowns. In stock at most oil supply stores.

SKINNER-SEAL
EMERGENCY PIPE CLAMPS for safe, sure, lasting repair of splits and rust holes in pipe. No pressure too high. Anyone can apply in a few moments. Made in all sizes, ½" to 12" for steel and C.I. pipe. Stocked by practically all oil supply stores.

Complete line of Repair Clamps. Send for Catalog 54!

M. B. SKINNER CO.
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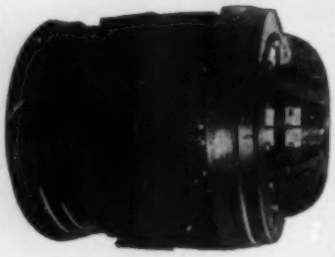
MOLE
Pipeline Cleaner



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CRUDE LINES
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FOR DETAILS WRITE

Pipeline Cleaners Co.
Fort Madison, Iowa

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PHOTO ELECTRIC PANEL
Automatically turns Tower Lights ON and OFF in accordance with FCC regulations
FLASHER PANEL - Automatically Flashes Beacon Lamps — with balanced load provisions.
ALARM PANEL - Automatically provides signals indicating failure of any lamp, power or control.

Model LC 201
TOWER LIGHTING CONTROL UNIT
(for Two Light Levels)
Model LC 101 (for Single Light Level)
Model LC 301 (for Three Light Levels)
Models also available with separate Alarm Signal for each Beacon Lamp.
Write for descriptive Bulletins

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. . . our SPY HOLIDAY DETECTORS are as near as your telephone—in fact, in emergencies our own plane assures immediate service.

Rugged equipment for dependable holiday detection on ¼" to 36" pipe . . . signal—bell, light and spark . . . unaffected by dew or frost.

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PIPE-WRAP TAPE

Positive Protection for Buried Pipe

Here's pipe protection by the roll. Pipe-Wrap is made of stretchy, inert polyethylene with a pressure-sensitive adhesive to provide a tough, continuous barrier against rust, acids, alkalis and electrolytic currents. Saves time and money.

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MOST ENGINE BUILDERS DO!

The most effective PIPE LOCATOR in the world

FIELD PROVED

the award winning

"Signalmaster"

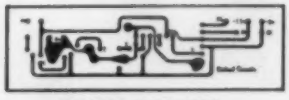
TRANSISTORIZED

PIPE LOCATOR

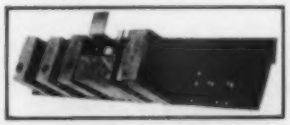
MODEL TR-1A

Utility and Construction Companies, Municipalities are unanimous in agreeing that MODEL TR-1A has proved most effective for locating mains, services, valves, conduit, high voltage lines, telephone cables. Easily separates parallel lines and can be used to trace non-metallic pipe lines. Complete piping systems traced out.

SPECIFICATIONS: Size of cases when clamped together: 9½" x 12½" x 5½" • Size of transmitter and receiver boxes, each: 9½" x 12½" x 2¾" • **Operating weight,** transmitter: 4½ lbs. • **Operating weight,** receiver: 4¾ lbs. • **Circuit:** Transmitter—one transistor, Receiver—six transistors • **Batteries:** Transmitter—4 size C flashlight cells, Receiver—4 size C flashlight cells • **Switching:** a. Automatic power switching for all "on-handle" operations. b. Automatic "turn-off" when set is not being used.



ETCHED CIRCUITRY



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SEVEN TRANSISTORS

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Leading Electronic Manufacturers 1933
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Most Machinery On Display at the
INTERNATIONAL PETROLEUM EXPOSITION
Was Lubricated by
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LUBRICATOR DIVISION
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New Literature

Fire Equipment

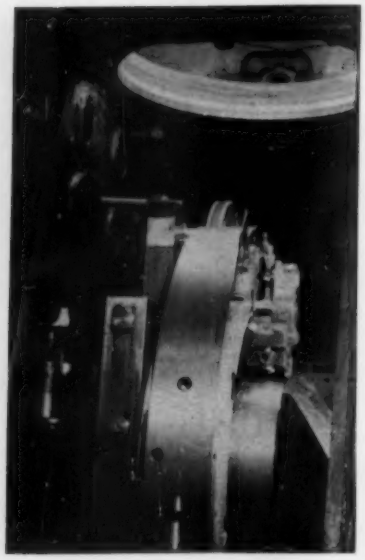
A 1960 line of fire equipment, including hand portable extinguishers, stationary fire equipment, piped systems, and large capacity mobile equipment, is displayed in a new catalog. Featured is the manufacturer's "Monitor" extinguisher that contains 2¾ lb of dry chemical in a spherical shell which can be removed after use and replaced with a fresh factory-filled one. *Ansul Chemical Co.*

Circle number (109) on reply card.

Free "Novelty"

Construction workers and others in the pipeline industry will be interested in obtaining one of these watchfob-keychain combinations featuring either the International TD-25 crawler tractor or the manufacturer's Model 95 Payhauler. Available now. Ask for yours. *International Harvester Company.*

Circle number (110) on reply card.



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- Accurate High Quality Maintenance And Machine Work

The small engine crank pictured above was restored in close quarters without dismantling engine. Our portable machines can solve your problems and save you money. Crank pins from 5½" through 20" in diameter accurately refinished in place at great saving in cost. **Let us help you minimize down time.**

Worn and damaged flywheel fits refinished in place.

In our shop crankshafts of any size or type completely refinished. Shafts straightened and broken shafts successfully repaired.

Most modern methods used in rebabbitting and machining engine and turbine bearings.

All types of heavy power plant equipment serviced with special attention given to emergency repairs.

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Non-Flammable Cleaner

For EFFECTIVE

Equipment Cleaning

at

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WELDING FITTINGS

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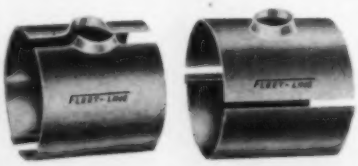
REDUCERS: Concentric and eccentric. Nominal pipe sizes 1" to 30", ASA B16.9, ASTM A234. Schedules 10 to 160, stainless steel, and other alloys. Special lengths and sizes.

SADDLES: Conventional, and for pressure vessel heads. Nozzle sizes from ¼" to 24". Fleet-Line saddles weld neatly into place in much less time, and with much less welding rod.

Full encirclement saddles.



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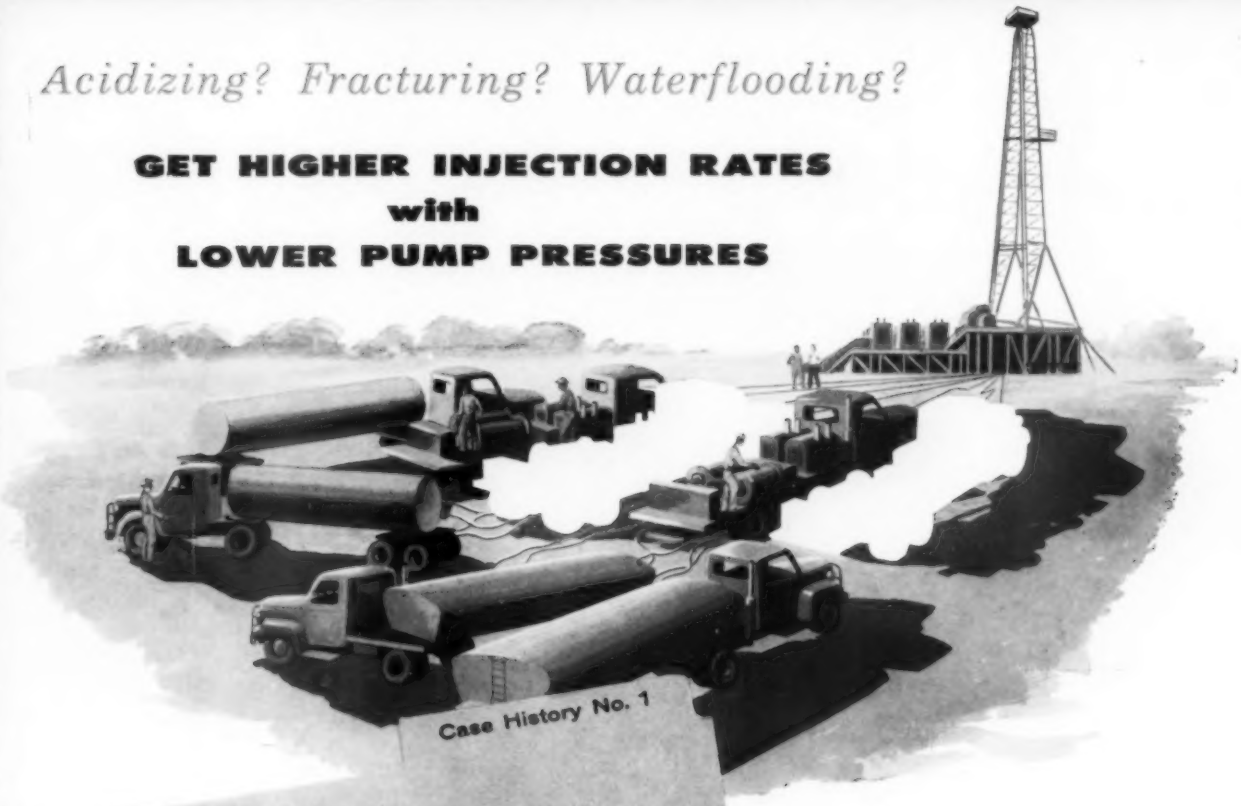
GET HIGHER INJECTION RATES with LOWER PUMP PRESSURES



Case History No. 1

Area – West Texas
Formation – Ellenberger Dolomite
Depth – Below 12,000'

BEFORE VIBRO-FRAC, acidizing injection rate averaged .15 bbls. per minute at 6500 p.s.i.

VIBRO-FRAC treatment started with perforating six feet of the casing with E-Gun and three VIBRO-PERFORATOR shots. This was followed by two open hole type VIBRO-FRAC charges in a 19' section of open hole and two casing type VIBRO-FRAC charges in the six foot section of cased hole.

After VIBRO-FRAC, acidizing injection rate started at 1.9 bbls. per minute at 5800 p.s.i. The injection rate increased to 7.3 bbls. per minute and the pressure dropped to 2600 p.s.i.

Case History No. 2

Area – West Texas
Formation – Devonian Chert
Depth – Below 8,500'

BEFORE VIBRO-FRAC, this formation would not take acid in offset wells.

The twelve foot zone of interest was perforated with 72 E-Gun holes and three VIBRO-PERFORATOR shots. Three casing type VIBRO-FRAC charges were spaced in the twelve foot zone.

AFTER VIBRO-FRAC, formation took acid at the rate of 2.4 bbls. per minute at 1500 p.s.i.

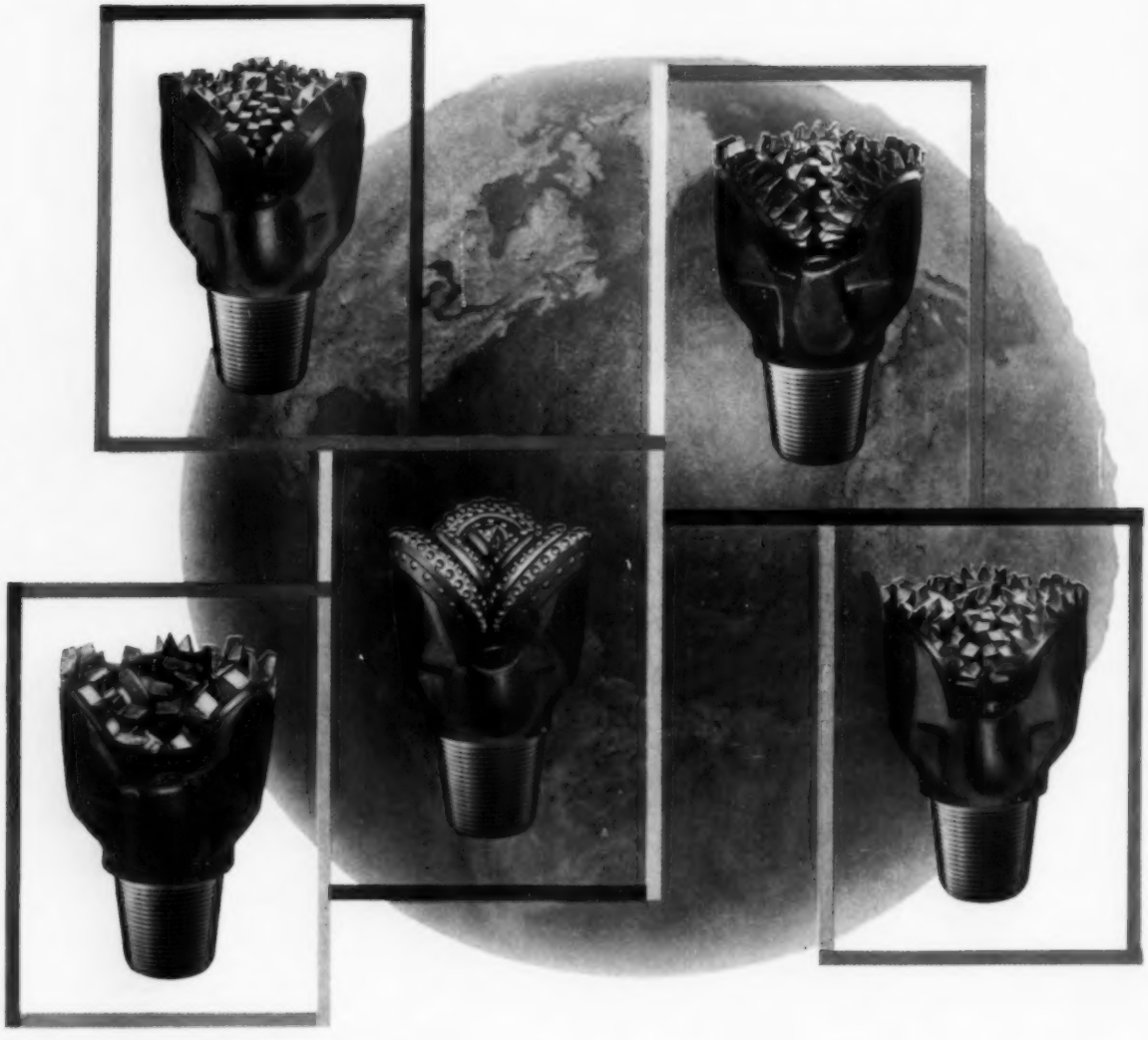
Acidizing a formation can mean the difference between a commercial producer and a dry hole. But how do you acidize a formation that won't take acid?

Many formations require extremely high pump pressures. Some formations won't break down at all. For these wells pre-treatment with VIBRO-FRAC, Lane-Wells explosive well stimulation service, makes acidizing practical. Selective fracturing produced by VIBRO-FRAC treatment opens up the formation — lets the acid in to do its work.

Improved VIBRO-FRAC charges can be run without depth or pressure limitations. Ask your Lane-Wells man how VIBRO-FRAC can help you with acidizing—or any type of fluid injection problem formations.

LANE-WELLS COMPANY
A Division of Dresser Industries, Inc.
P. O. BOX 1407 HOUSTON 1, TEXAS

VIBRO-FRAC and VIBRO-PERFORATOR Reg. U. S. Pat. Off. by Petroleum Tool Research, Inc.



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